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A badly disabled locomotive undergoing extensive repairs

HOSPITAL FOR DISABLED LOCOMOTIVES (SEE PAGE 352)

Future Internal-Combustion Engines—I*

The Physical Processes, Mechanical Methods, Energy Utilizations and Possible Improvements of These Motors

By Prof. C. A. Norman, Ohio State University

In this paper the physical processes underlying the conversion of combustion energy into power are discussed and the various methods of producing the pressure differences neecssary for the operation of ordinary heat motors. Theoretical and practically attainable energy utilizations of engines and turbines of the compressor, explosion and evaporation types are given and some possible lines of improvement are pointed out. Improvements are found to be possible with all three types. The possibilities of the compressor motor and the steam plant are especially emphasized.

As an illustration of what scientific investigation might bring in the future, certain promising results with electrical combustion batteries are mentioned.—Editor.

An investigation by the United States Department of Agriculture reveals the fact that 68 per cent. of all tractor engine trouble occur in magnetos, spark-plugs and carbureters or in the accessories of the present-day automotive engine. Bearings, cylinders and piston rings, valves and springs, lubrication and starting systems, that is to say, the parts common to all classes of combustion engines, give rise to only 32 per cent. of the troubles. From the point of view of reliability alone we have then a most serious reason to be on the lookout for some new type of automotive engine.

The reason from the point of view of fuel utilzation is even more compelling. An engine may be considered as having good carburetion that turns into shaft power more than one-fifth of the fuel energy supplied it. Four-fifths are regularly wasted in our automotive engines. Yet, the fuel must be a peculiarly high-grade one, a liquid meeting severe requirements of volatility, liquidity, etc. The question of continued supply of such a fuel is becoming a serious one. But there are weighty considerations beyond this. In an airplane, fuel has to be carried by engine power. In all aeronautical craft high fuel consumption means a serious reduction in cruising radius. In ocean-going cargo vessels it means a reduction in available revenue space. From purely practical points of view the queston of fuel economy, no less than the question of the nature of the fuel, is a momentous one. The question of what a fuel will do for us is wholly a question of what sort of a process the fuel is put through in the engine. What happens to it? Just in what way is combustion turned into power?

It is very unfortunate that in dealing with this question engineers have so far insisted upon being even more abstruse than scientists. The scientists strive to understand what actually goes on. They have by wonderful methods of analysis and experimentation arrived at a point where we feel that we almost *see* things which, strictly speaking, must remain invisible. We can "see" the individual effects of an electron, a body two thousand times smaller than the smallest atom. We know very accurately the velocities of gas molecules, of which there are a billion billion in a cubic inch; we know how these velocities are distributed. We can *see* how heat changes into power and power into heat.

In contradistinction to this the engineers persist in dealing with "cycles," an entirely fictitious and artificial something which has no real counterpart in nature, a set of traps really that have got many a very clever inventor into difficulties. To make a high-grade stationary engineer understand the "cycle" operating in his steam turbine, or the inherent "efficiency" of that cycle, one would first have to make him study a textbook of thermodynamics; whereas to show him how the velocities of the steam molecules are converted into the velocity of his turbine blades is a simple thing, requiring hardly any preparation whatsoever.

In this paper the attempt will be made to look at the working processes in internal-combustion engines as processes, not as cycles; although naturally in a paper of the scope of the present one the attempt must remain very sketchy and incomplete.

NATURE OF COMBUSTION AND ENERGY UTILIZATION.

Combustion as usually understood in practice is the more or less violent combination of chemical atoms into new molecules. A number of carbon atoms are tied together with a number of hydrogen atoms to form a hydrocarbon molecule. Two atoms of oxygen are tied together to form a molecule of oxygen. These two molecules arrive in the neighborhood of each other. The attraction between the oxygen atoms on the one side and hydrogen and carbon atoms on the other being extremely strong, the hydrocarbon molecule as well as the oxygen molecule is torn to pieces; the individual atoms rush to each other and molecules of carbon dioxide and water vapor are formed.

The force of the impact of the atoms is such that the new molecules are hurled through space with tremendous velocities. At 3,000°F. the velocity of a carbon dioxide molecule is approximately 3,500 ft. per sec., that of a molecule of water vapor 5,500 ft. per sec. A temperature of 3,000°F. is easily obtained in our internal-combustion engines. The velocity varies with the square root of the temperature. The number of molecules in a cubic inch is, as stated, about one billion billions. Fundamentally our problem is then to utilize for our power purposes the velocities of incredibly small particles, flying through space with the velocity of projectiles. This problem is complicated by the fact that the velocities occur in all conceivable directions. The molecules shooting through space collide with each other and rebound. Any gas above absolute zero temperature (0° Abs.) may be thought of as a swarm of molecules dashing about in all directions at incredible speeds.

Looking for the moment apart from the electrical utilization of combustion, about which more is said at the end of the paper, two ways of utilizing these velocities present themselves.

In the first place the molecules wherever they dash against a wall exert, by their combined impact, pressure on that wall. This pressure can be easily expressed in figures. It is

$$P = 1/3\ nmv^2, \text{ where}$$

P = the pressure per sq. in.
n = the number of molecules per cu. in.
m = the mass of each individual molecule
v = their speed in in. per sec.

The product nm is the mass of the gas per cubic inch, a quantity well known for all gases.

If the pressure of the gas on the wall is to move the latter, it is manifest that the pressure on the other side of the wall must be lower, so as not to counterbalance the "inside" pressure. The establishment of a pressure difference on two sides of a wall is then necessary to utilize for power purposes the gas pressure exerted by chaotic impacts. On this principle all piston engines, whether reciprocating or rotary, are founded.

A second way out, however, is possible. The velocities of the molecules are chaotic on account of the rebounds in all directions. Suppose the molecules in one certain direction were entirely removed, or at least very much reduced in number. Then those dashing in this direction would not rebound, but would proceed untrammeled on their way. A stream, or jet, in this direction would be established which could be used on a turbine wheel. A gas turbine at once suggests itself. The difficulty here is the high velocities with which the molecules move; then also the high gas temperature incident to combustion. In any case we recognize that removing molecules in one direction means reducing the pressure in this direction. Here again the fundamental problem is the establishment of a pressure difference.

Now as we shall see at the end of the paper, it is possible to establish pressure differences in solutions by chemical means and utilize these pressure differences for the direct production of electricity.

Looking aside from this, however, and confining ourselves to methods more usually recognized as belonging to the field of mechanical engineering, these methods of pressure, or vacuum, production are perfectly well known and not of unlimited number. They are:

(1) By compressors and exhausters
(2) By explosions in confined spaces
(3) By boiling in confined spaces
(4) By condensation
(5) By heating and cooling

USING COMPRESSORS AND EXHAUSTERS.

One of the first engines to operate on this principle was that of Brayton. The compressor and the working cylinders of this engine are shown on page 35. A charge of gas and air is drawn into the compressor cylinder, compressed and discharged into a receiver. From there a small amount passes continuously into the working cylinder through the grating *a* and is kept burning. At the beginning of the working stroke the admission valve *b* opens and a full charge passes into the working cylinder, igniting as it passes through the flame. The grating prevents the flame from striking back into the receiver. The compressor can be driven from a common crank-shaft or a beam.

Gas and petroleum engines of this type were developed with great energy by Brayton. Two of them were used some time in the seventies to operate a pair of boats on the Hudson River. Yet the grating and other parts gave mechanical trouble. More serious was the fact that the fuel economy was extremely poor. Only 6 per cent of the fuel energy was turned into power. The energy utilization of the Otto explosion engines appearing simultaneously was twice as high. For further progress it becomes necessary for us to look into the nature of energy utilization.

It is commonly known that a pound of fuel can produce a perfectly definite amount of heat or of work on combustion. Engineers mostly assume that the amount of heat and the amount of work are identical and are given by the so-called heating value of the fuel. This heating value is determined by burning the fuel in a bomb calorimeter, either with oxygen or with a substance containing oxygen, like chlorate of potassium. As a matter of fact, the heating value and the maximum work doing capacity are identical only at a temperature of absolute zero. At any other temperature the maximum work doing capacity may be either greater or less than the heating value. At ordinary atmospheric temperature of about 70°F. the conditions are given in Table 1.

TABLE 1. HEATING VALUE WORK DOING CAPACITY AT APPPROXIMATELY 70 DEG. FAHR.

Fuel	Ratio Work Capacity to Heating Value	B.t.u. per lb.	Work Capacity hp.-hr. per lb.
Hydrogen burned to water......	0.94	48,700	19.20
Carbon manaxide to dioxide....	0.98	4,300	1.70
Carbon to carbon dioxide.......	1.00	14,700	5.80
Carbon to carbon monoxide.....	1.21	5,390	2.12
Hexane to carbon dioxide and water	1.03	21,400	8.40
Alcohol to carbon dioxide and water	1.03	13,800	5.30

As will be seen the difference between the work and heat values of our two most important fuels, coal and fuel oil, carbon and hexane, is not enough for practical men to bother about. At the same time, that carbon burned to carbon monoxide can be extracting work energy from the atmosphere do 21 per cent more work than that furnished by its heat value, is a fact somewhat too interesting to leave entirely unnoticed even in a paper intended for practical men. We are dealing here with working processes of the future, not knowing even what the fuels will be. It is well to have one's eyes open to all the possibilities of the situation, even if they do not appear to be of any particular interest now.

The Brayton engine turned 6 per cent of the heat or work capacity of the fuel into power. How much could an engine of this type give as a maximum? The working cylinder, before it can give any useful power, must drive the compressor. We must arrive at a ratio between compression and expansion work. When a gas is compressed it means that the molecules are hurled into each other from an advancing wall, their speed increasing with each impact against this wall. The temperature of the gas is inherently nothing else than the velocity energy per molecule, $\frac{1}{2}mv^2$. The gas is heated up. Conversely, when the gas expands the molecules recoil from a receding wall, or a receding mass of molecules and the impacts slow them down. The gas cools. In compression we store up work in molecular energy; in expansion we convert molecular energy into work.

If the terminal temperatures and pressures of a compression and an expansion are the same, then the compression work and the expansion work per pound of gas are the same. If the initial temperature of expansion, measured from absolute zero, is five times the end temperature of compression, then the expansion work between the same pressure limits is five times the compression work. In all our internal-combustion engines by far the main part of the working fluid both before and after combustion is nitrogen from the air. For a rough estimate we can therefore regard the whole engine process as one carried out by compressing, heating and expanding nitrogen alone.

We see immediately that for compressor engines to have a large margin of net power, it is necessary for

(*Continued on page 354*)

*Reproduced from *Jour. Soc. Automobile Engineers.*

Internal Actions and the Performance of Electric Furnaces

Causes of Fluctuations in Load, Limitations to Short-Circuit Current, Stabilization of Arc and High-Power

By W. K. Booth

In the installation of electric furnaces, the effect of the power factor at which the furnace normally operates on the power supply lines is in many cases not given sufficient study and consideration. As a result the furnace operation often causes disturbances on the power service lines which could have readily been avoided if an adequate survey of the power conditions had been made at the start.

It is not merely necessary to know that the furnace will operate with a power factor of 0.90 to 0.95, but the investigation must go deeper and determine just what this means. The most desirable condition is that the furnace should operate at the highest possible power factor without causing undue disturbances at the generating station or to other consumers of electricity from the same power plant.

To understand fully the operating conditions of an electric arc furnace for melting steel, it is, perhaps, desirable to consider what takes place in the furnace when melting a charge of cold steel scrap.

Considering the "direct arc" furnace, where the electrodes are suspended vertically through the roof and the arc forms between the electrodes and the steel scrap, the action which takes place is substantially the same regardless of the make or type of the furnace. To form the arc the electrode is lowered until it comes in contact with the scrap and then raised out of contact so that the arc is drawn in the space between the electrode and the scrap. At the instant of contact of the electrode with the scrap there occurs practically a short circuit in the furnace, the current surge being limited only by such resistance to the flow of current as may be furnished by the charge in the furnace and the furnace leads and the reactance of the circuit. In other words, the amount of the current surge under such conditions is limited by the impendance of the furnace circuit.

During the early stages in melting down there is considerable fluctuation of the arc, that is, the arc goes out and is reformed by again bringing the electrode in contact with the charge and drawing the arc. There are three reasons for this:

(1) The scrap melts away from beneath the electrodes and so causes the arc to break.

(2) To maintain an arc the cathode must be kept at a high temperature, which is difficult with an alternating current, because at one instant the electrode is the cathode and the steel scrap the anode, and at the next instant the relationship is reversed. It is much harder to keep a hot spot on the steel scrap than it is on the carbon electrode because steel conducts heat away more rapidly than does carbon. Besides steel melts and vaporizes more readily than carbon and heat is used in producing these changes. Consequently in starting an arc furnace on a cold charge, until a small pool of molten metal has formed under the electrode, the arc will go out a number of times owing to the fact that the metal cannot be kept hot enough between reversals of the current to serve as the cathode and so continuously maintain the arc. After a pool of molten metal has formed, however, with a quantity of slag, the arc will become quite steady.

(3) Pieces of scrap may fall against the electrode causing a temporary short-circuit surge, the duration of which will depend largely upon the size of the piece of scrap, the manner in which it rests against the electrode, and the time required for the electrode-raising mechanism or regulator to raise the electrode out of contact with the scrap. The reason for this is that, in melting, the electrode bores a hole down through the charge until a pool of metal forms upon the hearth of the furnace and the arc forms between the electrode and the pool of metal, the scrap gradually melting in from around the electrode. Sometimes pieces fall in and strike the electrode as shown in Fig. 1.

Therefore, it will be seen that during the first stages of melting, for perhaps the first half hour of the heat, there will be more or less current fluctuations due to the conditions in the furnace previously mentioned and the maximum value of such short-circuit currents will depend upon:

(1) The full load power factor of the electric furnaces and transformer equipment, that is the power factor of the furnace load measured at the high-tension busbars of the power supply.

(2) The low-tension voltage at which the furnace operates.

(3) The character of the scrap used in the furnace.

In Fig. 2 is shown a curve giving the ratio of the short-circuit current to the full-load current for various full-load power factors. This curve is based on the assumption, which is only approximately true, that on short-circuit the resistance is practically zero and is simply an indication of the maximum current values which might be attained under certain conditions in the furnace. It is hardly necessary to give the detailed calculations, the points on the curve being computed from the fact that

Short-circuit current = full-load current ÷ sin Θ where cos Θ is the full-load power factor and the resistance on short-circuit is assumed to be zero.

The resistance in the furnace may vary over a wide range depending upon the character of the scrap which

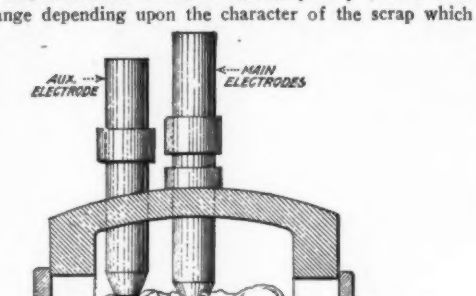


Fig. 1—Piece of metal falling into pit bored by arc and short-circuiting same

forms the charge. For example, if the entire charge is composed of small scrap such as axle turnings, machine turnings or borings, the resistance to the passage of current will be very high, due to the large contact resistance between the large number of small pieces of scrap. Therefore, if the voltage applied to the furnace is low, the resistance offered by the scrap may be so great that there will be no short-circuit surge; in fact, no arc may form at all, and the furnace will not carry full-load current when the electrodes are first lowered, but only after a portion of the scrap has been heated by resistance and welded together will the resistance of the scrap be lessened to such an extent as to permit an arc to form. If the voltage applied to the furnace is considerably higher, there may be enough difference of potential to maintain the arc and also overcome the resistance of the small scrap so that the full-load current will flow when the electrodes are lowered. In this case the large resistance of the scrap woud materially help to limit the current surges in starting the furnace and much faster melting would take place at the beginning than with a lower voltage and no arc forming. In other words, with the same charge and 75 volts applied to the furnace, the entire 75 volts might be required to force full-load current through the resistance of the scrap. However, if the furnace voltage were 150, the resistance drop across the scrap might be about 75 volts and there would remain approximately 75 volts for the formation of the arc.

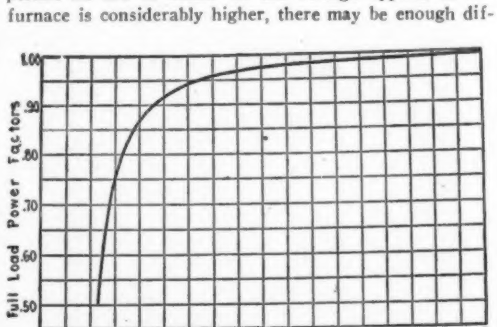


Fig. 2—Indication of maximum short circuit that can be formed

On the other hand, if the charge were composed of relatively large pieces of scrap, there would be little resistance drop in the charge, and the conditions would more nearly approach those shown in the curve of Fig. 2. It might be mentioned that, in order to limit short-circuit surges on starting and make an "easy" start, it is sometimes desirable to place the heavy scrap in the bottom of the furnace and cover it with a quantity of turning or other light scrap.

It is impracticable, however, to install an electric furnace under the conditions that only a certain kind of scrap be used, and the furnace must be capable of operating with the widest possible range of scrap materials. The voltage at which the furnace operates must also be such as to work efficiently under all conditions regardless of the quality of the scrap. Consequently the furnace must be designed to operate with a full-load power factor such that the highest possible current surges in starting will be limited to values which will not cause serious disturbance on the power lines.

Before the orders for the equipment for an electric furnace have been placed, a survey of the power conditions should be made by the engineers of the power company in conjunction with the electric furnace engineers and the electric furnace equipment then designed to operate with such a power factor as is suitable for the power company lines. Some of the factors which have to be determined are:

(1) Kva. generating capacity of the power company's station.

(2) Whether or not the power lines for the electric furnace run directly from the busbars of the generating station to the electric furnace substation, or run to an intermediate transformer substation of the power company. In the latter case it will be necessary to know the connected load on this transformer substation other than the electric furnace load and the character of this load.

(3) Whether or not a special line has been run from the generating station to handle electric furnace load, and if any other power service is taken from this line.

(4) If other power customers receive power from the same transmission line, it should be determined what the character of this load is and whether or not any portion of it consists of lighting.

(5) The approximate distance from the power station should be determined, as the reactance of the power lines can be taken into account in determining the characteristic at which it is decided for the electric furnace to operate.

If investigation of the foregoing subjects is made before the electric furnace user places his orders for the furnace and substation equipment, an electric furnace instalation can be made which will cause little trouble to the power company and will frequently save a considerable expense that may develop if it is necessary to install additional equipment to cut down current surges after the furnace equipment is placed in operation.—*Electrical World.*

Electricity for Increasing Flow from Oil Wells

The output of oil-wells generally diminishes rapidly after some time. This is caused by the stopping-up of the pipes used for tapping the oil in the well. The cold air which penetrates freezes the rock, and the paraffin-wax contained in the oil solidifies and obstructs the piping.

To overcome this trouble it is necessary to heat the rock, hot water, steam, or hot air being used. The action of these sources of heat is, however, limited; they cannot be employed for depths of 400-500 metres, and the rise in temperature at much smaller depths than this is very slight.

For some time past thermo-electric devices have been used for the purpose. The heating resistance is placed at the bottom of the well, and the object is easily attained. The naphtha is heated to 200° or 300° C., and under the pressure of the gas given off is forced out of the well.

The depth of the well is practically negligible, the device being just as effectual in 1,000-metre wells as in shallower ones.

This method has been used successfully by the Germans in Galician and Rumanian wells which had been blocked up prior to their occupation of the territory. (Abstract by *the Technical Review from L'Industrie Electrique.*)

A Theatre for Studying Camouflaged Ship Models

Laboratory Reproduction of Conditions that Submarines had to Contend With

The art of camouflage which was developed to a high degree during the great war called for a great deal of scientific research. In its earlier stages the effect of various colors and patterns was largely a matter of guess work but the problems were soon subjected to careful investigation and laboratory experiment. As the coloration was aimed to deceive the submarine it was very necessary to study camouflage from the eye piece of the periscope. To that end a theater was constructed in Rochester, New York under the direction of Lt. L. A. Jones. Here lighting conditions at sea were imitated as closely as possible and models of ships were studied through a persicope from the interior of a chamber in which lighting conditions of a submarine were faithfully reproduced. Photographs of this interesting theater and the apparatus with which it was equipped were recently published in the transactions of the Illuminating Engineer's Society and they are reproduced here by courtesy of the Society together with a description of the apparatus:

"In order that the efficiency of any scheme of deception coloration be carried out it was necessary to imitate as completely as possible all of the conditions under which such a system is supposed to operate. These conditions include such factors as the quality, quantity and distribution of the light on the protectively colored craft, the conditions of the observations by the enemy, etc. Since the most urgent problem was that of protection of surface craft from attack by submarines, that phase of the subject was given the most attention and the apparatus designed and built was for the study of that particular problem.

"In order to reproduce lighting conditions as closely as possible a shallow tank 14 feet in diameter and 12 inches deep was constructed upon which when filled with water, the model to be examined was floated as in Fig. 1. Over this tank a dome of diffusing material was erected which when lighted from without gave a lighting condition upon the model similar in quality and distribution to that resulting from the sky illumination, as in Fig 2. Inside of this dome a single high intensity electric lamp was mounted on a movable arm so arranged that direct light similar to that from the sun could be thrown on the model, from any desired direction, thus producing the shadow effects of sunlight, as in Fig. 2. Behind the model was mounted a painted curtain carried on two rolls so arranged that a background of any desired brightness and quality could be brought into position for examination of the various models under specified conditions.

"The models were mounted on a floating support which could be brought into any orientation with respect to the observer, by the use of a cam and motor set in motion at a known speed. They were then examined through a special periscope mounted in a small truck, as in Fig. 3, enclosed so that the observer could be subjected to the same conditions of lighting as exist in the interior of a submarine thus keeping his eyes in the same condition of adoption as those of a submarine observer. The truck was mounted on a track 130 feet long at a scale of 1 to 256 in both yards and knots, which approached the tank on which the model was placed for examination. This truck was driven either towards or away from the model at any desired velocity by means of a motor and a speed control cam. The periscope was mounted so that the model was viewed by reflection from a mirror as shown in Fig. 4, movable in such a way that the model appeared to be traveling across the course of the truck at any desired angle. The speed of this mirror was regulated also by the motor which drove the truck. This made it possible to approach a vessel going at a known speed, and from it make observations at certain intervals to determine the effect of any camouflage pattern that might be selected."

Fig. 1—Model floating in shallow tank, ready to be examined from the periscope which travels on the tracks in the foreground

Electrostatic Effects on Airships

By Prof. Gordon S. Fulcher

Mixtures of hydrogen and air in proportion between certain limits may be exploded by a minute electric spark. Such mixtures may occur near any opening such as a valve of an airship from which hydrogen is being emitted into the air. And sparks may pass from one part of an airship to another or from the airship to a cloud, or to the ground, if electric charges are acquired which produce sufficient differences of potential. Also, when a balloon is being filled with hydrogen from cylinders, explosions sometimes occur which seem to be due to electric charges developed in the connecting tubes. An understanding of the electrostatic effects involved could only be obtained by experiment.

Certain questions were formulated and then the answer given below were obtained as a result of experiments conducted at Princeton University and in the wind tunnel at the Navy Yard, Washington.

1. Is the balloon fabric used on airships a good insulator or not? *Answer:* The conductivity depends upon the moisture content of the surrounding air, but ordinary rubberized cotton fabrics are sufficiently good conductors, even when thoroughly dry, practically to equalize the potential of the whole balloon surface in about a minute. A sample of rubberized silk fabric was found to be a good insulator.

2. Are the hemp ropes used in suspending the car good insulators? *Answer:* No; from an electrostatic point of view they are good conductors.

3. Are rubber rings forming part of valve seats good insulators? *Answer:* Yes, when they are clean.

4. As a result of the electric field near the surface of the earth—from 50 to 200 volts per meter—the difference of potential between points at different heights above the surface may be very great. Will the sudden change of altitude of a conducting balloon cause it to acquire large charges? *Answer:* The charges induced on a conducting balloon, as can be shown by mathematical reasoning from the known laws of an electric field, depend upon the electric field in the region before the arrival of the balloon and upon charges induced on nearby conductors because of the disturbing effect of the balloon; therefore, the sudden transference of a balloon from a region of high potential to one of low potential will not change the charges on the balloon, provided the strength of the field is unchanged and provided the balloon is not brought near a conductor. The maximum field around an originally uncharged spherical balloon is three times the strength of the field into which it was brought, if no conductors are near; the maximum field between such a balloon and the flat surface of the ground just before contact is made is five times the original field; protuberances, especially sharp points, projecting from the balloon will have a greater field immediately around them than that stated above, increasing with the sharpness and the distance they project from the main surface of the balloon; but, except during an electric storm

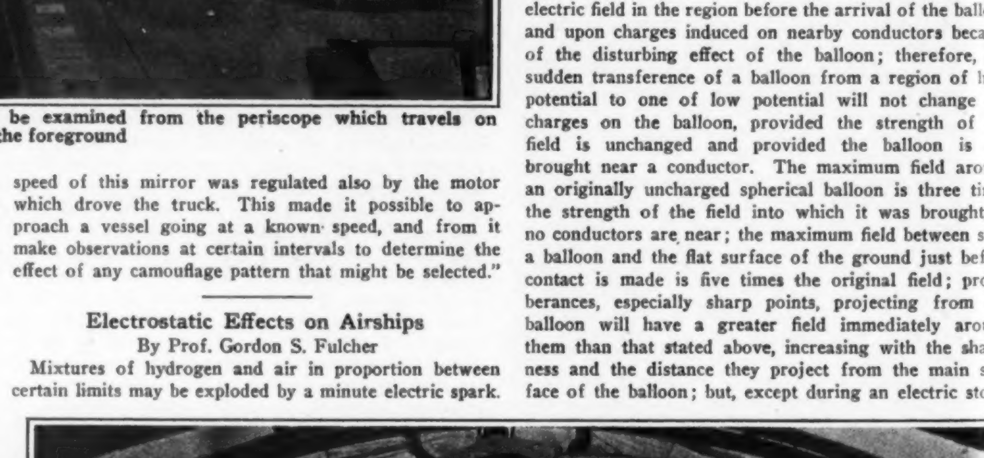


Fig. 2—Method of securing equal distribution of light from the artificial "sun," mounted to give any desired azimuth or altitude of sun

and when a balloon approaches a highly charged cloud, the field around any balloon due to charges induced on it will be too weak to cause sparks.

5. May an airship acquire an electric charge as a result of being driven through the air at high speed? *Answer:* Yes, if the speed is sufficiently great; rubberized cotton fabrics become negatively charged, while rubberized silk fabrics become positively charged.

6. How does the effect depend upon the speed? *Answer:* It increases very rapidly with the speed, in fact, approximately as the sixteenth power of the speed, being about 50,000 times as great at 60 m.p.h. as at 30 m.p.h.

7. Does the effect depend upon the dust and moisture in the air? *Answer:* Yes; it depends chiefly if not wholly on the solid and liquid particles held in suspension in the air; dust and water particles seem about equally effective; with ordinary air the effect is small for speeds below 60 m.p.h., but in the case of smoke or mist large effects may be obtained with 40 m.p.h.

8. How does the effect depend upon the angle the fabrics makes with the direction of its motion? *Answer:* It increases rapidly with the sine of the angle, approximately as the sixth power, so that the effect is practically zero when the fabric is moving tangentially, and is a maximum when the fabric is moving perpendicularly to its plane; the effect is therefore associated with impact rather than with skin friction.

9. Does the charge increase uniformly with the time? *Answer:* No; it increases less and less rapidly and tends to approach a limiting value.

10. Does a piece of fabric show signs of "fatigue"? *Answer:* Yes; in successive experiments with the same piece of fabric the effect was found to decrease progressively faster than could be due to the gradual decrease in the dust content of the air.

11. When a cylinder full of compressed hydrogen is insulated and then the gas is blown out through a copper tube, may the cylinder become charged? *Answer:* Yes.

12. How does the effect depend upon the rate of discharge? *Answer:* It increases rapidly with the rate; marked effects were obtained when the gas was discharged through a copper tube, 3/16 in. inside diameter at the rate of 4 cu. ft. per min.

13. Does the charge increase uniformly with the time? *Answer:* No; the cylinders tested became negatively charged at first, but soon the charge was neutralized and then became more and more positive, increasing more and more rapidly until high potentiols were reached; the amount of condensed moisture in the gas also increases with the time; since there is a rapid cooling of the valve and outlet tube by the cold expanded gas; this suggests that the effect is largely due to condensed moisture.

14. Can the effect be prevented by filtering out the dust and water droplets? *Answer:* Yes; by passing the gas through a rather large plug of glass wool; the speed of discharge is reduced somewhat, of course, but may still be sufficient to empty a cylinder in a few minutes.

15. Can hydrogen issue from the valve of an airship with sufficient speed to charge up the valve? *Answer:* According to computation the speed may be several hundred feet per second, which may charge up the valve if there is sufficient dust and moisture in the gas; no direct tests have been made as yet to determine whether in fact the valve of an airship may become charged.

16. Is a brush discharge as effective as a spark in exploding mixtures of hydrogen and air? *Answer:* Experiments made with explosive mixtures of hydrogen and oxygen showed that the soft brush or corona discharge, such as is observed around an electrostatic influence machine when in operation, is not effective in causing the explosion of such mixtures.

Dangers and Their Prevention

1. *Danger from sparks between various parts of an airship*—If the fabric and ropes are conducting, the only danger is that due to the rubber ring around the valve seat, which may become charged by the outflowing gas and cause a spark to pass through the gas to the valve. It would be a wise precaution to coat the rubber ring with graphite tallow or in some other way to make its surface conducting, and also to connect the valve and the seat by a wire firmly fastened to each. Glycerine and other petroleum products are non-conducting.

2. *Danger from sparks to ground on landing.*—Since the airship may become highly charged as a result of motion through smoke or mist, the difference of potential between it and the earth as it descends may be sufficient to cause a spark. To avoid danger the landing rope should be a fairly good conductor—hemp rope will answer—and should be attached to the balloon in such a way as to insure a rapid discharge of the whole surface.

3. *Danger from sparks to a person after landing*—

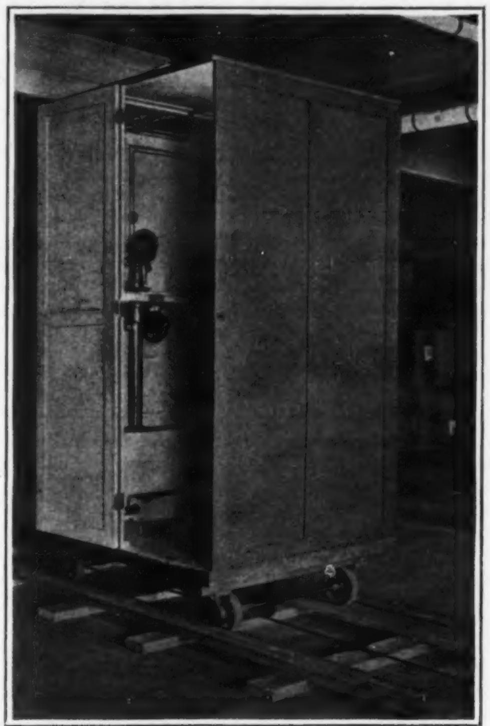


Fig. 3—Submarine inclosure, periscope, tracks and cable

A spark may pass to a person approaching a valve either because the balloon or because the person is charged. In dry weather, especially, a person may easily become dangerously charged by friction. To avoid danger it would be wise to make it a rule to touch the fabric with a moistened hand at some distance from the valve before touching the valve itself.

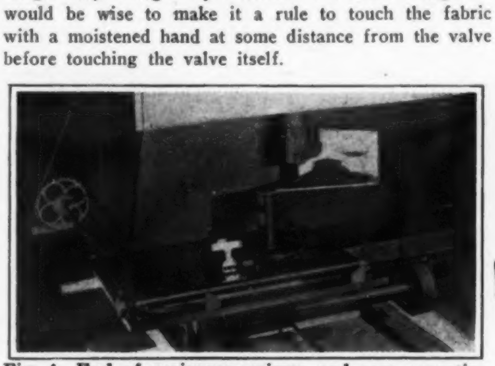


Fig. 4—End of periscope, mirror and cam operating the speed of the mirror

4. *Danger from sparks to a charged cloud*—If the balloon chances to be in the path of a lightning flash between earth and cloud it will probably be destroyed; but since the electric capacity of the balloon is small, a spark between it and a cloud can be prevented by relieving the electric tension by means of discharging points located as far as possible from the explosive mixture of gases. A sharp point or crown of points made of non-corroding metal, projecting above the dorsal fin of the airship and connected by wire to the steel framework of the fins, would eliminate most if not all of the danger.

In the case of kite balloons, it may be noted in passing, the danger of being struck by lightning is greatly increased by the telephonic connection to earth; discharging points would increase rather than diminish the danger; during a storm it would be better to insulate the balloon and cable by means of a solid rubber or sealing wax section of rope.

5. *Danger from brush discharge due to wireless*—Whether or not the brush discharge is dangerous depends upon whether it is a soft glow or is disruptive. Tests of the wireless outfit installed in an airship at Akron showed no signs of any brush discharge at all. At any rate, the energy is so small and the number of wires and points is so great that a dangerous brush discharge is extremely unlikely to occur. Hence the only danger arises from the possibility of sparks between two metal parts when contact happens to be poor. If, then, care is taken to see that a poor electrical connection between adjacent metal parts does not occur within five feet of the balloon, it would be no safer to insulate the car from the balloon than to use metal suspension wires throughout.

6. *Danger in connection with filling balloons from cylinders*—The danger arises from differences of potential between the fabric hose and the cylinder in case the hose blows off. The hose should be securely fastened to the metal pipe leading from the cylinder, and good electric connection should be assured by cleaning the surface of the metal. In dry weather it would be well also to connect the cylinder to a metal bar driven into the ground through the top dry crust.[1]

Supplementary Report

General Statement—I still believe that (1) it is desirable that the outer surface of the balloon envelope should be conducting so that dangerous differences of potential between the various parts may be made impossible and so that the balloon may be rapidly discharged before landing; (2) that the inner surface of the envelope should be conducting to prevent dangerous differences of potential from being produced by the friction of one surface upon another during inflation; (3) that, for similar reasons, the ropes suspending the car, and especially the landing rope, should also be conducting, and that the latter should be so well connected to the envelope and other parts of the airship as to insure the rapid discharge of the airship before landing. The questions considered here are how sufficient conductivity may best be secured.

1. *Are cotton balloon fabrics sufficiently conducting?*—The conductivity of cotton is associated with the fact that it is hygroscopic, and therefore depends upon the temperature and humidity of the surrounding atmosphere. Perfectly dry cotton cloth is a very good insulator, but when the relative humidity is over 60 per cent. cotton is a fairly good conductor. For the lowest humidities recorded for the Atlantic seaboard the conductivity is still appreciable, but so small that I cannot as yet state definitely that the conductivity would always be sufficient to eliminate all danger.

Conclusions—(1) Remebering that the airship is most likely to acquire frictional charges in going through mist or ice crystals—that is, when the humidity is necessarily high—I should conclude that the danger arising from the poor conductivity of the cotton outer ply of the envelope would be very slight.

(2) If a cotton inner ply is used, it may be kept sufficiently conducting by maintaining the humidity of the gas filling of the balloon up to 50 per cent. or more.

(3) All danger could be eliminated by increasing the conductivity of the lower surface of the envelope around the valves and rope-ends by adding a suitable coating.

Various methods of rendering surfaces conducting are described. Among them are:—

Use of aluminium foil—Aluminium foil can be obtained which weighs only .05 oz. per sq. yd., or about 3 lb. for an airship. The difficulty would be to stick it on durably. If sheets of aluminium foil about ten times as thick could be applied to the fabric while the rubber was still sticky, perhaps a durable metal coating could be secured which would not only be conducting and light in weight but would also have the valuable property of reflecting heat rays so as to prevent rapid changes of temperature of the balloon. The cost of the foil should be less than $0.25 a square yard. Gold foil would be more difficult to apply and more expensive.

(*Continued on page 360*)

Fig. 5—Studying effects of design with models in convoy formation

* An investigation undertaken at the request of the Bureau of Construction and Repair, Navy Department.

1 A conducting fabric is preferable because it prevents dangerous differences of potential from arising between the various parts of the balloon, because it enables the whole surface of the balloon to be rapidly discharged, and because it prevents the accumulation of charges produced by friction of one fold of fabric on another and when the ripping panel is used.

The Flower Paint of the Aztecs*

Identification of the Long-Lost Brilliant Orange Dye of Early Mexico

By W. E. Safford, U. S. Bureau of Plant Industry

Vegetable dyes were used by the aborigines of all parts of America for ornamenting their utensils, staining their bodies, or coloring their baskets and fabrics. Many of the textiles found in the prehistoric graves of Peru are remarkable for their beautiful and permanent colors. Few of these, unfortunately, can be traced to the plants from which they were derived. The introduction of foreign dyes has been disastrous. Their cheapness and the facility with which they can be transported has caused them to be widely adopted in place of native dyes, the preparation of which is fast becoming obsolete. The ancient Mexicans made use of a number of beautiful pigments, mostly vegetable, for the picture-writing of their celebrated codices. Nearly all of their colors can be identified. A crimson was obtained from the cochineal insect, reared upon a cactus (*Nopalea coccinellifera*). This they called nocheztli, or "prickly-pear-blood." With it they sometimes combined other ingredients, especially the leaves of the Melastomataceous plant called tezoatl, or texhautl. From the reddish-yellow aril of the seeds of *Bixa-orellana* they derived a pigment called achiotl. This is now widely used throughout the world, and is known commercially as annatto, or arnotto. A bright yellow was obtained from a leafles parasitic plant, *Cuscuta tinctoria*, called zacatlaxcalli. From logwood *Haematoxylon campechianum*, and the closely allied *Haematoxylon brasiletto*, called uitzquauitl, or huitzcuahuitl, they obtained a purple, and other shades, resulting from various additional ingredients. The use of this wood is now world wide. From the twisted pods of *Caesalpinia coriaria*, called nacascolotl, they obtained a fine black. These pods, known commercially as cascalote or dividivi, are now an important source of tannin. Another dye-plant, interesting on account of its old-world affinities, was their xiuhquilitl, *Indigofera suffruticosa*, more commonly known as *Indigofera anil*, and very closely allied to *Indigofera tinctoria*, from which most of the commercial indigo is derived; and another beautiful blue, called mohuitli, was obtained from *Jacobinia mohintli* and *J. umbrosa*.

One of their colors, however, which all writers on Mexico mention, has hitherto remained unindentified. This was called xochipalli, or "flower-paint," a name also applied to the plant itself. It is the object of the present paper to announce its rediscovery and to give a description, by means of which the plant can be identified with certainty. The most remarkable fact in connection with this plant is that, although it was described and figured more han three centuries ago, it has remained hither to unidentified. It is widely spread in Mexico. In the present State of Guerrero there is a town, Xochipalla, the name of which signifies "the place where the xochipalli abounds." The celebrated traveller, Gemelli-Careri, who visited this town in 1697, while en route from Acapulco to Cuernavaca, passed through a neighboring district where the girls gathered xochipalli flowers and made of them a cosmetic paste. The Proto-Medico, Dr. Francisco Hernandez, who was sent by his sovereign Philip II in 1570 to New Spain to study its resources, gave the following description of this plant, illustrated with a rude drawing, a fac-simile of which is here shown.

"Xochipalli is an herb six cubits in length, with sinuous (pinnatified) leaves somewhat like those of Arte misia, stems a finger thick, flowers resembling those of the cempoalxochitl [*Tagetes erecta* L.], but smaller and of a reddish yellow color, and roots slender and long. It is widely spread in the *tierras calientes*, and is an herb well known to everybody. Only the flower is used, the which is moderately hot and of an agreeable odor and taste, comforting the heart, curing maladies of the womb and ulcers, especially those of the mouth. But the chief use of the flowers is for dyeing wool and painting images and objects of a yellow color which in a certain manner verges to red, for which object they are boiled in water together with an alkali, after which the juice is expressed and strained, yielding a color which is used by painters and dyers."

A search for the name xochipalli, or its modern variant, suchipal, in Ramirez and Alcocer's *Sinonomia vulgar y cientifica de las plantas* Mexicanas was without result, nor could it be found in the *Nueva farmacopea Mexicana*. In Siméon's monumental *Dicciónnaire de la langue Nahautl*, however (p. 701 the importance of this plant is attested by the following definitions: "*Xochipalli* ou *Xuchipalli*, Herbe dont la feuille ressemble a celle de l'artémise et sert à teindre les étoffes en janue rouge; couleur rouge, rose. RR. *xochitl, palli*." Robelo, also, in his *Diccionario de Aztequismos* (p. 444) refers to it as follows: "Suchipal (Xochipalli: *xochitl*, flor; *palli*, color: 'flor-color,' ó 'color de flor'). Yerba cuya hoja se parece á la artemisa, y sirve para teñir las telas de amarillo, rojo ó naranjado." On page 447, note 23, he says "Esta planta no está clasificada;" and on page 449, under geographical names, he includes "Xochipala (xochi-pal-la: *xochi-palli, ó xuchi-palli, suchipal; la*, variante de *tla*, particula abundancial):" "Donde abunda el suchipal."

In response to letters of inquiry the writer received replies from several Mexican botanists, all of whom following Hernandez's description, were disposed to refer the plant in question to the genus Tagetes, which includes the so-called "French" and "African" marigolds of our gardens, both of which are flowers of Mexican origin, held in high esteem by the Aztecs and used by them in certain religious rituals. Dr. B. P. Reko of Oaxaca referred it to *Tagetes patula* and Dr. C. Conzatti thought that it might possibly be *Tagetes multiseta*. In a letter dated July 5, 1918, Dr. Canzatti says that, although Hernandez declares the xochipalli to be an herb well known to everybody, no one could be found who knew it: even the oldest natives in the vicinity of Oaxaca were ignorant of such a plant. Since Hernandez described it as having "flowers resembling the cempoalxochitl (*Tagetes erecta*) but smaller,"' Dr. Conzatti was inclined to refer it to the smaller cempoalxochitl, *Tagetes multiseta*, a dried specimen of which he enclosed in his letter. That the plant in question could not possibly belong to the genus Tagetes was shown at once by the form of the involucre subtending the flower-head, which according to Hernandez's drawing, was not at all cup-shaped, or tubular like that of Tagetes but composed of several distinct linear bracts. A comparison of Hernandez's rude illustration with herbarium specimens of Tagetes showed that the plant in question could not possibly be included in the same genus with them. His figure represents a composite with flower-heads not unlike those of a Coreopsis, but the accompanying leaves are artemisia-like as stated in the original description. The widely spread ray-flowers, a few in number, are three-toothed at the apex. On one of the heads they have fallen off, indicating that they are not persistent like those of Tagetes. The disk flowers form an erect cylindrical bundle, while the entire head is subtended by an involucre not at all like that of the genus Tagetes, but composed of a few linear sepal-like bracts as stated above.

Failing to find the plant in the genus Coreopsis, the writer carefully examined the plants belonging to allied genera. At last, in the genus Cosmos, he came upon a species corresponding in all respects with Hernandez's figure. The long sought Xochipalli proved to be *Cosmos sulphureus*, a species which, though figured the latter part of the eighteenth century by two eminent botanists, had never been associated with the dye-plant described and figured by the great protomedico a century previously. To verify the discovery, a decoction of the flowers was made for the writer by Dr. L. A. Hawkins, Plant Physiologist, of the Department of Agriculture. Almost immediately the water become suffused with an orange tinge, and on the addition of a very small quantity of alkali it changed to a rich orange-red, the color of the xochipalli described by Hernandez.

Cosmos sulphureus, as pictured by Hernandez in 1576 (left) and as found today (right)
a, dish-flower; b, achene

Though never hitherto connected with the classic "flower-color" used by the Aztecs in painting their codices, *Cosmos sulphureus* is not a rare plant. Specimens of it were lacking in the United States National Herbarium until 1886, when it was encountered by the veteran explorer Dr. Edward Palmer in the vicinity of Guadalajara, Jalisco; and five years later he collected it at Culiacan, Sinaloa, bringing back with him from this locality seeds from which plants were propagated at Washington. The account of its introduction into cultivation in the United States is told by Dr. J. N. Rose in *Garden and Forest* for December, 1895, where an excellent figure of it was published. It is now represented in the United States National Herbarium by specimens from many other parts of Mexico. Seeds were recently obtained by the writer, and he now has a number of vigorous young plants of the true xochipalli growing in one of the greenhouses of the United States Department of Agriculture.

Description

Cosmos sulphureus is a tall, pubescent annual composite, growing usually about four to seven feet high, with stems as thick as the thumb and bipinnatifid or tripinnatifid leaves, not unlike those of the common *Artemisia vulgaris* in form. The flower heads, borne on long slender peduncles, are subtended by a calyx-like involucre composed of two series of eight bracts each, the outer bracts linear and green the inner broader and scarious. The flowers vary in color from bright orange to deep reddish orange. The heads are composed of eight broadly ovate ray-flowers, three-toothed at the apex, spreading at right angles to the axis and soon falling off, and fertile tubular disk flowers forming a compact erect cylindrical bundle. The exserted anthers are black with orange tips, and the style is branched, terminating in two slender tips. The fruit is a linear akene nearly an inch long, including the slender barbed peaks, and the pappus consists of two slightly hispid awns.

* From *Jour. Wash. Acad. Sciences.*

The Recovery of Fume from Silver Refining Operations*

Description of a Recently Installed Fume Precipitator Operating on the Cottrell System

By W. G. Smith and A. A. Heimrod

The application of the Cottrell electrical precipitation processes found early recognition as a standard means of removing the suspended particles of fume from exit gases arising from copper and lead smelting operations, as well as in the recovery of the fume from the further operation of refining the gold and silver by-products of these two major metals into commercial or marketable form.

It is the intent of this article, first, to touch briefly upon one of the earliest commercial Cottrell installations, placed in operation in one of the Eastern refineries, and, second, to describe in detail the latest developments in fume treatment by the Cottrell processes on virtually the same kind of fume. It is assumed that the readers of this article are familiar with the general principles of electrical precipitation, therefore these are not touched upon. Those, however, who wish to familiarize themselves on the terminology involved can do so by referring to the literature on the subject in which will be found a very comprehensive discussion of its theory.

The first commercial installation of this kind was the Cottrell plant installed at Perth Amboy, N. J., where, in September, 1913, a box type precipitator was put into operation for the recovery of values in the fumes coming from furnace operations for the refining of copper slimes. This precipitator was of the horizontal gas flow type and was built in one section, having an active length of approximately 13 feet and an active width of 8 feet. There were thirteen sets of discharge electrodes, making thirteen aisles or passageways in parallel through which the fume and gases passed and were subjected to the high voltage discharge from the discharge electrodes. These discharge electrodes consisted of 1-inch lead strips sharpened at the edges and spaced at equal intervals on the discharge electrode supporting frame. The gases, before they entered the precipitator, were passed through a scrubber and spraying system, where some of the fume in the gases was removed and the gas temperature lowered to approximately 150 deg. F. The spraying, in addition, performed the very vital function of humidifying the gases properly for later treatment in the precipitaor and ultimately the scrubbers were eliminated. The operating voltage was 40,000 volts, with a total power consumption of 3 to 4 kw. The box type treater on this problem caused considerable trouble due to building up of the fume on the collecting and discharge electrodes, and this, together with the nature and the composition of the fume, necessitated continual attention by the operator in order to keep the precipitator in service at a high point of efficiency. This precipitator was, however, operated continually until the summer of 1916, when a pipe type installation was placed in service.

Since the installing of the initial electrical precipitation installation at Perth Amboy, the art of precipitation of silver refinery fume has been advanced to a marked degree. The latest development along this line is the installation which has very recently been completed and placed into successful commercial operation at Chrome N. J.

The electrical precipitation installation on the silver refinery gases at this plant is installed at the end of a considerable length of flue system in which is also located a large settling chamber, spraying and scrubbing apparatus. The precipitator proper consists of a steel frame supporting lead top and bottom headers, conneeted by means of lead precipitator pipes. Three units are porvided, each of which is suitable for handling approximately 4000 cu. ft. of gas per min. at 115 to 150 deg. F. at a velocity of 7 ft. per sec. through the pipes, or in case of necessity 8000 cu. ft. per min. at a velocity of 14 ft. per sec. through the pipes with only a very slight decrease in efficiency.

Each precipitator unit is 8 ft. 8 in. x 8 ft. measured from the inside of the precipitator column supports and has an overall height from foundation to the peak of the open top header of 34 feet.

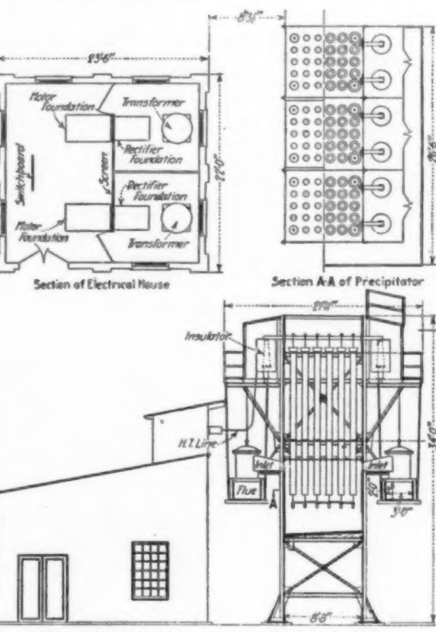
All of the parts of the precipitator which come directly in contact with the gases are made entirely of the very best high grade electrolytic lead, free from impurities of antimony. It has been found that the gases containing selenious and selenic acid destroy lead which contains as low as 0.1 per cent antimony, therefore no lead containing antimony was used in the construction. Any steel work that might be subjected to exposure to the gases was covered with lead in such a way that no fume could come in direct contact with the iron.

* From *Chemical and Metallurgical Engineering.*

The fumes and gases from the furnaces used in the silver refinery operations are conducted into the bottom header through an inlet at each side of each unit close to the top of the bottom header chamber. Each of these inlets is provided with a liquid seal gas-tight jug damper in order to permit the shutting off of any unit and clear it entirely of gas without interfering with the operation of the remaining units, thereby giving to the whole installation flexibility and assuring continuous operation. These jug dampers are located on and supported by the top of the 2 ft. x 3 ft. rectangular bustle pipe extending along each side of the precipitator units. This bustle pipe is in turn supported by hanger rods from the main structure. (See illustration.)

The bottom header chamber is made of 8-lb. lead, the end walls being supported by lead clips fastened to the structural steel frame. In the bottom of the header box a 6-in. diameter lead drain pipe is provided in order to facilitate the flushing out of the collected precipitated material into settling tanks located alongside the precipitator. Ready accessibility to the bottom header is provided by means of doors which can be easily opened to inspect the electrode systems.

Each precipitator unit has 30 collecting electrode pipes 16 ft. long. Twenty-six of these pipes have an internal diameter of 8-in. and the four corner pipes have an internal diameter of 11 in. The increased diameter of these corner pipes permits installing of a stiff electrode to steady the discharge electrode system and prevent it from swinging or swaying due to irregularities of gas flow or in electrical conditions. This avoids the use of insulators in the bottom header and thereby eliminates possibilities of insulator leakage trouble at this point.



Cross-section and plan of the Cottrell installation at Chrome, New Jersey

The precipitator pipes extend into the bottom header 4 ft. The gas inlets are so arranged that the gas flows in near the top of the bottom header box, circulates around the pipes, flows down to the bottom, then up through the pipes and discharges into the top header box. This arrangement tends to break up any irregularities in the flow of the incoming gases, equalizes the gas pressure in the bottom header, tends to heat all of the pipes to a uniform temperature and thus insures proper distribution of the gas in the various pipes. The gases passing through the electrical field are cleaned and are discharged at the top of the precipitator into the top header and to atmosphere. The solid and liquid particles carried by the gas are collected on the inside surfaces of the collecting electrode pipes, from which the precipitate is periodically washed into the bottom header by means of a washing system installed in the top header. This cleaning operation is performed only on idle units, the gas temporarily being diverted to other units and the electric power line switch opened. This can readily be done, as high voltage selector switches have been installed in the electrical house whereby a precipitator unit can be put in or taken out of service without disturbing the operation of the electrical equipment or gas flow to the remaining units.

The top header of each precipitator unit is lead lined throughout and open to atmosphere at the top. The end walls of these headers have been provided with two openings to allow the high tension framework to pass through to the steel insulator compartments, where it is supported on 3-ft. high corrugated pillar type insulators. These are properly hooded with steel hoods in order to protect the insulators from moist gas and bad weather conditions.

The installing of the collecting electrode pipes was accomplished by passing a mandrel through the pipes so as to remove any irregularities such as projections or dents. They were then passed through the lead-covered steel top header supporting plate, which was drilled to allow the pipes to pass through freely to the second steel lead-covered supporting plate 9 ft. 9 in. below the top header. After the pipes were in place they were burned to the sheet lead covering on the supporting plates and to the top plate of the lower header, thereby making the pipes hang plumb and assuring a tight joint around pipes where they enter the bottom header.

The discharge electrode system of each unit consists of, first, four corrugated pillar type insulators,[1] two on each side of the precipitator unit, insulating the high tension frame from ground, these insulators, as stated before, being protected against bad atmospheric conditions by means of sheet iron hoods. Second, the electrodes are made up of a star section lead-covered iron wire, carefully centered in the pipes and supported from 2-in. pipe bus bars. The corner pipes have stiff electrodes made of 1½-in. lead-covered extra heavy wrought iron pipe. Around that portion of the electrode that is in the precipitator pipe is a spiral of star section lead-covered iron wire[2] the same as used in the other pipes. Third, the electrode system is tied together at the bottom by a sway frame to the stiff corner electrodes, and on the end of each electrode in order to hold it straight in the center of the pipe is a 20-lb. lead weight.

Electrical Equipment

The electrical equipment for the transformation of the available power supply at 250 volts direct current to the required potential of 65,000 volts is placed in a building close to the base of the precipitator.

The supply lines run through a main line switch and fuses mounted in a steel cabinet on the wall and from this point to the switchboard. This arrangement makes it possible to disconnect entirely the main switchboard buses and all auxiliary wiring from the power supply line.

The switchboard consists of two slate panels, each having a main and a lower section, and each controlling independently one of the duplicate sets of electrical apparatus. The lower panel sections are reserved for the motor starter face plate, manual operating handle, overload and under voltage trip coils. The main sections of each panel have mounted upon them all the control equipment except the motor starters, and high tension switching devices. On each main section is a single pole circuit breaker in the motor circuit (protecting that side of the circuit not protected by the overload coil on the motor starter); a main line motor switch; a generator field switch and a field discharge resistance; a generator field rheostat operating handle (with rheostat on the back of the panel); a double pole, overload trip, under voltage release, circuit breaker in the line from the generator to the transformer; a rheostat switch; a double pole double throw reversing switch and a transformer tap switch in this same line; and a voltmeter and an ammeter in the transformer circuit. By means of a potential plug the voltage may be measured either at the generator terminals or the transformer terminals, the difference being the voltage drop across the line rheostat (plus a small line drop).

Generator Equipment

The two motor generator sets consist of a 40-hp., 220-volt, 150-amp. motor and a 25-k.v.a., 220-volt, 113-amp. single-phase 60-cycle generator. The mechanical rectifiers are directly connected to and therefore operated in synchronism with the motor generator set. Near the rectifiers are the high voltage transformers rated as follows: 25 k.v.a., 200 volts low tension, 75,000 / 70,000 / 65,000 / 60,000 / 55,000 volts high tension; 60 cycles,

(*Continued on page* 359)

[1] Research Catalog No. 5-J-3.
[2] Research Catalog No. 3-E-1.

A general interior view of a repair shop

Traveling hoists

Hospitals for Disabled Locomotives

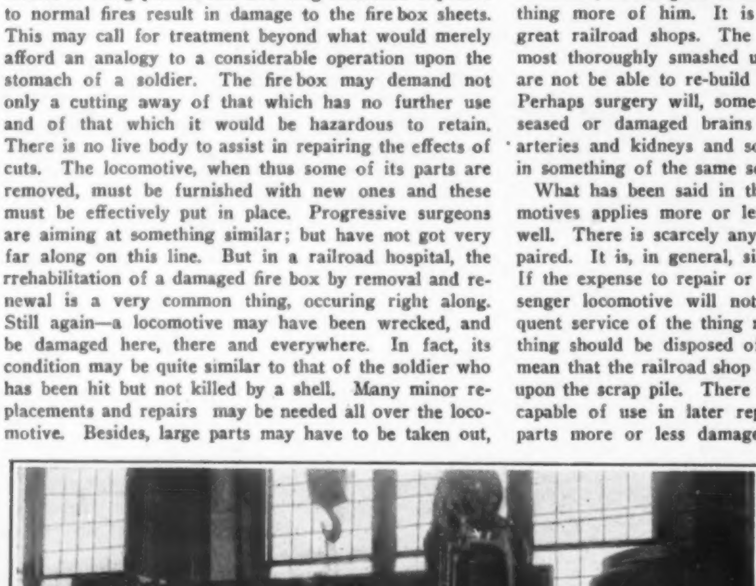
The Machinery of Railroad Repair Shops

A great railroad system must provide for the rehabilitation of its damaged and broken locomotives and rolling stock in general in much the same way that a great army must look out for its gassed and wounded and sick. A big passenger locomotive gets "square" places on certain of its wheels from the too-quick slow-downs and stops at principal stations. Such slow-downs and stops may show what perfect control the engineer has of the great locomotive and train, but these spectacular "stunts" are hard on driving wheels. Other rolling stock, too, may get wheels with similar flat spots, when the brakes lock and the train slides. Such damaged wheels call for similar attention to that bestowed by the army surgeon on a broken and lacerated arm. Again, the roaring and savage fires, often necessary when the locomotive is being pushed and also long continued exposure to normal fires result in damage to the fire box sheets. This may call for treatment beyond what would merely afford an analogy to a considerable operation upon the stomach of a soldier. The fire box may demand not only a cutting away of that which has no further use and of that which it would be hazardous to retain. There is no live body to assist in repairing the effects of cuts. The locomotive, when thus some of its parts are removed, must be furnished with new ones and these must be effectively put in place. Progressive surgeons are aiming at something similar; but have not got very far along on this line. But in a railroad hospital, the rrehabilitation of a damaged fire box by removal and renewal is a very common thing, occuring right along. Still again—a locomotive may have been wrecked, and be damaged here, there and everywhere. In fact, its condition may be quite similar to that of the soldier who has been hit but not killed by a shell. Many minor replacements and repairs may be needed all over the locomotive. Besides, large parts may have to be taken out, remodeled and returned. Or, a whole new part may be necessary. What has to be done is, in a way, comparable to what has to be done to the soldier when a major operation is required. It is often necessary, however, to go far beyond the surgeon and hospital force. So much has to be done to the locomotive, and can be done, that the result is a machine in great part new—a rebuilt piece of apparatus. The surgeon cuts away, assists Nature, and rearranges dislocations; but does very little in the way of renewals. If a man's leg is cut off, off it stays; and not only is the old leg taken completely out of service, but a new one is not put in place. When the surgeon cuts of the limb, and looks out for the healing of the cut region on the remaining stump, and takes care of the patient's general health in the meantime, he has gone to his limit. No one expects anything more of him. It is altogether different at the great railroad shops. The locomotive must have been most thoroughly smashed up if the mechanical experts are not be able to re-build it and set it to work again. Perhaps surgery will, some day, be able to remove diseased or damaged brains and hearts and lungs and arteries and kidneys and so on, and in their place put in something of the same sort.

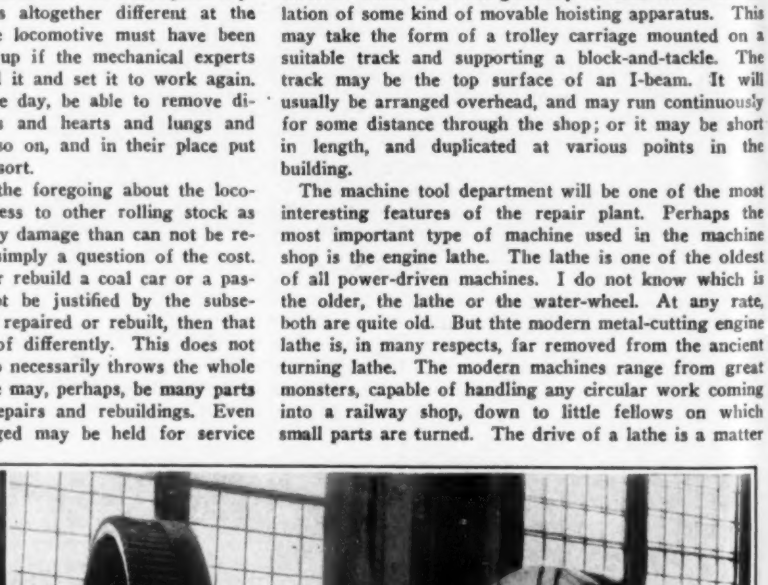
What has been said in the foregoing about the locomotives applies more or less to other rolling stock as well. There is scarcely any damage than can not be repaired. It is, in general, simply a question of the cost. If the expense to repair or rebuild a coal car or a passenger locomotive will not be justified by the subsequent service of the thing repaired or rebuilt, then that thing should be disposed of differently. This does not mean that the railroad shop necessarily throws the whole upon the scrap pile. There may, perhaps, be many parts capable of use in later repairs and rebuildings. Even parts more or less damaged may be held for service in some other car or locomotive. For example, a rod, though severely worn and in consequence unusable in a unit similar to that from which it came, may be saved with the view of using it in connection with a unit of smaller size. A little work put upon it may make it quite suitable for entrance upon a new life in other surroundings.

A little reflection may, perhaps, convince one that the mechanical resources of a big shop, serving a great railroad, may advantageously cover quite a number of different departments. There should be various and capable means of shifting big and little weights about the shop. In fact, the character and amount of work may justify, for example, a big crane capable of lifting and transporting in the lifted condition an entire locomotive. Then there will generally be need for an installation of some kind of movable hoisting apparatus. This may take the form of a trolley carriage mounted on a suitable track and supporting a block-and-tackle. The track may be the top surface of an I-beam. It will usually be arranged overhead, and may run continuously for some distance through the shop; or it may be short in length, and duplicated at various points in the building.

The machine tool department will be one of the most interesting features of the repair plant. Perhaps the most important type of machine used in the machine shop is the engine lathe. The lathe is one of the oldest of all power-driven machines. I do not know which is the older, the lathe or the water-wheel. At any rate, both are quite old. But thte modern metal-cutting engine lathe is, in many respects, far removed from the ancient turning lathe. The modern machines range from great monsters, capable of handling any circular work coming into a railway shop, down to little fellows on which small parts are turned. The drive of a lathe is a matter



Using hydraulic press to force wheel on axle



Resurfacing the tread on locomotive driving wheel

of great importance. It must be capable of receiving and using enough horse-power to cut the metal. It must be capable of accepting the power at one speed and transforming this into power at another speed. Upon referring to one of the engravings, it may be seen that a big lathe is being operated by its own individual electric motor mounted on the head of the machine. The power of this motor must be considerable, in view of the heavy work that comes to this lathe. Otherwise, the chips would have to be thin or the feed slow. What is often wanted with a big lathe like this one is a slow but very powerful movement of the work past the cutting tool. Big, heavy chips may then be taken. Such an operation is a "roughing" one. Now an electric motor will furnish power in a rapid turning of its shaft. This is to be exchanged for a slow turning of the work. This is done through an arrangement of gear wheels. Later on, a thin chip is desired in order to effect a finishing operation. It would be very uneconomical, if the slow turning used in roughing were now continued. A rapidly removed, thin chip is what is wanted. The drive gears must be shifted so that this requirement may be met. Further, with work different from that on the lathe in the illustration, the cutting point may be continually at a different distance from the axis on which the work is rotating. Thus, instead of a cylindrical surface to be gone over by the cutting tool, the job may consist of flat work secured against the great face plate, the ends of some of whose slots are visible in the picture. With the tool beginning at the furthest point from the center and cutting a spiral chip running finally into the center itself, the radius of rotation of the work against the tool edge would be continually diminishing. If the work turned always at one rate of rotational speed, then a rate suitable to take off a chip of desired size at the periphery would be entirely unsuitable near the center. This would be uneconomical, unless provided for. One method would be to vary the power supplied. By suitably diminishing the horse-power as the radius of the cut shortened, a readjustment in so far as power is concerned would be effected. But this would still be uneconomical, as it would mean using a big lathe on a small job. It would at times be like using a big 5-ton motor truck to haul a 5-pound box of candy. It would do the job, but it would be expensive. So another method is found useful with lathes, and this consists in providing for a range of rotational speeds, the several speeds forming a series with proper intervals. With lathes, such changes are sometimes effected by the "cone pulley," by the cone pulley connected up with gears, by gears alone, etc. The greatest and most useful of machine tools is the thing that every railway shop must have. There may be but few individuals and the range of work may be somewhat restricted. Nevertheless, the smallest shop must have lathes or else go out of business.

Some of the modern developments of the lathe are not needed in a railway shop. Thus, the multiple-spindle, automatic lathe would hardly be especially useful, as its function is to make repetition work—that is, to make many things of exactly the same kind.

But a type of machine tool that one might not expect, but will find in some progressive railway shops is the grinding machine. Naturally, there have always been such grinders as the simply mounted emery wheels and the like. I do not refer to them, but to a class of tool properly described as the precision grinder. Grinding machines are used for a variety of purposes. They are usable for the purpose of producing a very smooth surface. Such surfaces are adapted, because of their absolute regularity, for such finishing treatments as copper and nickel plating. Many may think that electroplating obliterates inequalities of the surface; so that the tool marks made by a lathe would be swallowed up and a perfectly even finish produced. But this is not the case, practically, as the electro-deposits of metal reproduce the inequalities. But, the precision grinder has a nobler field of usefulness. It is the machine with which to produce an exact and even fit of the *precise kind* desired. Such fits are becoming more and more necessary. The grinding machine is perhaps the very best way to get them.

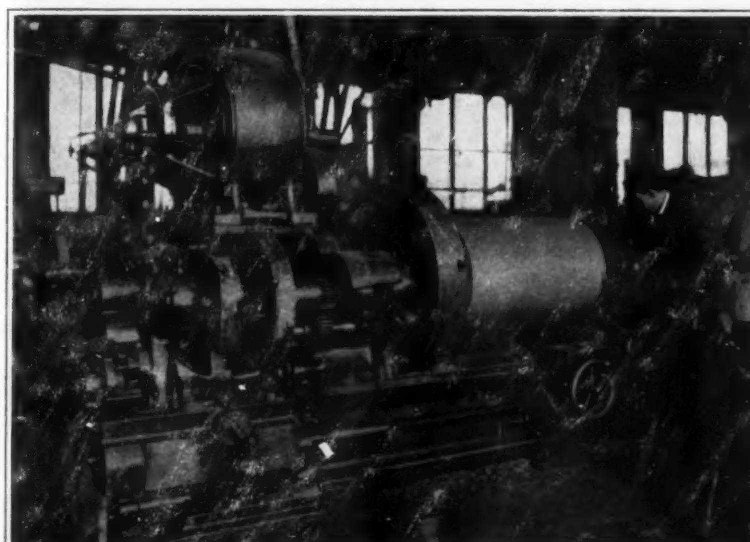
It may be a matter of surprise to some that fits should be difficult to get and that there should be varieties. The demand for varieties is the outcome of modern machine development. A light running fit is one thing and a close running fit is another, both referring to the relative movement when a shaft rotates in a hole or when a wheel rotates on a shaft. A press fit is quite another affair. Here no relative movement is in contemplation. The shaft is made a very small trifle larger than the hole into which it is to go. The two are then forced together by means of an hydraulic press. In one of the engravings, we have an example of this. A locomotive driving wheel is being pressed upon its axle by hydraulic pressure. The fit being made is a press fit. In the present case, the apparatus is capable of exerting a pressure of 250,000 pounds per square inch. Whether just that amount of pressure is being exerted in this particular case is another matter. That depends upon the resistance. If the press fit aimed at has not been produced by the grinding machine or other means, then the hydraulic press will avail nothing by way of correction. The amount of resistance will turn upon the excess of the one diameter over the other, the extent of surface involved, the character of the material, etc. However, if the mechanics and machines which precede have done their precise duty, the hydraulic press will force the two parts together and the fit will be what is desired. But if the excess of the one diameter over the other is less than it should be, the press will still force the two together, but the fit will not be as firm as that desired. On the other hand, if the larger diameter is in excess of what it should be, then the press will still force the two together—up to the limit of its capacity—but the fit will be tighter than desired, which may put unwarranted strains upon the weaker piece, or perhaps upon both. It may be gathered, then from this single example of a press fit, that precision methods are quite desirable in the railway repair shop. Unless the convex cylindrical part can be measured with great exactness and unless the concave cylindrical diameter can also be exactly determined, then the proper fit can not be made, except accidentally. Nor can this fit be made even with such means of measurement, unless there are adequate tools with which to make the final finishing cuts. The grinding machine offers the best solution to such a problem. It removes an infinitesimal amount at a time and does it with extreme smoothness and exactness.

The railway shops are beginning to increase their grinding facilities; but this is a refinement that has not yet been fully developed with them. That is to say, the railway shops, or the foremost of them, are using grinding machines for a good deal of work; but these machines are not yet in use, with the average shop, in adequate quantity and variety. Such shops fall behind the machine shops in certain other industrial lines. However, this matter is being pushed. As the grinder, in its various types, becomes everywhere prevalent in railway repair shops, there will also occur a corresponding development in respect to precision measurement.

While the railroad shop, dealing as it does primarily with repairs, has no especial use for the multiple spindle automatic lathe, nevertheless there are one or two developments which may be rated as being in the same class with that lathe. The automatic lathe will be equipped with, say, four separate and distinct hollow spindles, through all of which bars of stock are simultaneously fed. Four tools will simultaneously work on these bars, one on each. Four operations constituting a cycle will be alloted to these tools, one operation to a tool. One complex operation, performed by the machine as a whole upon the four bars, will effect a complete cycle of the simple operations. Between complex operations the relative positions of work and tools are shifted, so that each bar may now have wrought upon it the next simple operation. This is a wonderful piece of mechanism, now well developed and largely used in manufacturing repetition work. The railway shop has, by way of offset, one or two machines which perform two operations at once. Both operations are, however, performed upon a single piece of work. Thus, there is a machine which is a combination of a drill press and turning lathe. The middle connection of a locomotive driving rod requires to be bored out internally and turned externally. A single machine does both jobs at once. Perhaps it would be more accurate to describe the machine as a double lathe, which brings two tools to bear at a time, since the internal hole is not machined in just the way that a drill does it. In the engraving is shown a "double lathe" of this sort. The work turns around a vertical, and not a horizontal, axis. One tool is held in a hexagonal head above. This operates on the interior of the work. The other tool is fed horizontally from the side and cuts upon the exterior. The upper head may be provided with several tools, any one of which may be quickly brought into position by turning the head. In fact, in so far as the use of these tools go, the machine is a turret lathe turned up on end.

Turning lathes are employed in two principal ways—(1) the work is provided with conical holes at each end and then mounted between conical points called centers; and (2) the work is held to a face plate which rotates with the spindle in the head. The former method is more accurate but is, in general, only applicable to such work as the external cutting of cylindrical surfaces on rods and other long work. It has a great advantage, as the work may be taken off and later put back again without much trouble. The second method is applicable to discs and other short work. Once the work is removed from the face plate, it is next to impossible to get it back again in the exact position which it had before. A good many varieties of chucks and the like have been devised for holding the work to a proper position on the face plate. Naturally, once the work is secured in place and cutting begins, the cut will have its center in the prolonged axis of the spindle. It is desirable, however, especially with work where surfaces are already approximately correct, to get the work on the face plate to advantage—that is, so that the existing approximation may be adequately utilized. A little reflection may be sufficient to convince one that this may involve difficulty. In actual practice, the lathe operator may test the placing of the work before going ahead with

(*Continued on page 360*)



Slow moving drive for big work

Two-operation, vertical lathe

Future Internal-Combustion Engines

(*Continued from page 346*)

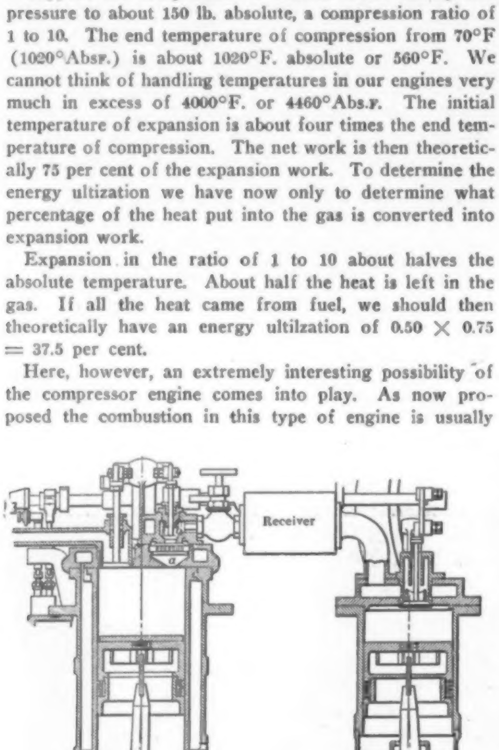
the expansion to be carried out at a much higher temperature range than the compression. The exact figures are:

Ratio of absolute initial expansion temperature to compression and temperature...	2	4	6	8	10
Net work, percentage of expansion work	50.0	75.0	83.0	87.5	90.0

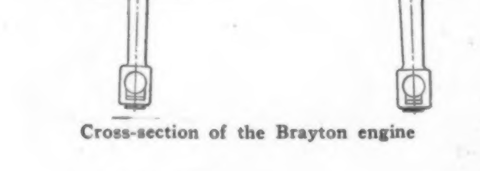
Suppose the compression is carried from atmospheric pressure to about 150 lb. absolute, a compression ratio of 1 to 10. The end temperature of compression from 70°F (1020°Absᴘ.) is about 1020°F. absolute or 560°F. We cannot think of handling temperatures in our engines very much in excess of 4000°F. or 4460°Abs.ᴘ. The initial temperature of expansion is about four times the end temperature of compression. The net work is then theoretically 75 per cent of the expansion work. To determine the energy ultization we have now only to determine what percentage of the heat put into the gas is converted into expansion work.

Expansion in the ratio of 1 to 10 about halves the absolute temperature. About half the heat is left in the gas. If all the heat came from fuel, we should then theoretically have an energy ultilzation of $0.50 \times 0.75 = 37.5$ per cent.

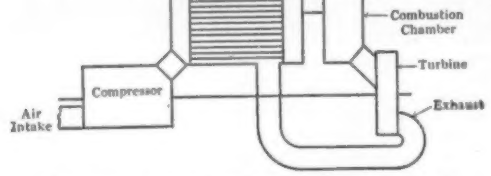
Here, however, an extremely interesting possibility of the compressor engine comes into play. As now proposed the combustion in this type of engine is usually



Cross-section of the Brayton engine



Utilizing a heat interchanger in a compressor engine



Combustion chamber and turbine wheel of the Armengaud-Lemale gas turbine

carried out not in the working cylinder but in the receiver. As shown schematically for a gas turbine, the compressor feeds air and a pump supplies fuel continuously to this combustion chamber. An extremely complete combustion of any kind of liquid or gaseous fuel can thus be obtained. Now, suppose we use the exhaust gases to heat the fuel air in a heat interchanger between compressor and receiver. Theoretically speaking the fuel has then only to make up the interval between the exhaust gas temperature and the maximum temperature used. Again, theoretically speaking, since the heat supplied is now exactly equivalent to the expansion work and no heat is lost in exhaust, we have here possibilities of attaining energy utilizations around 70 per cent. A similar possibility does not exist in the case of the ordinary explosion engine, where the exhaust heat is lost at least for purposes of power production in the same engine.

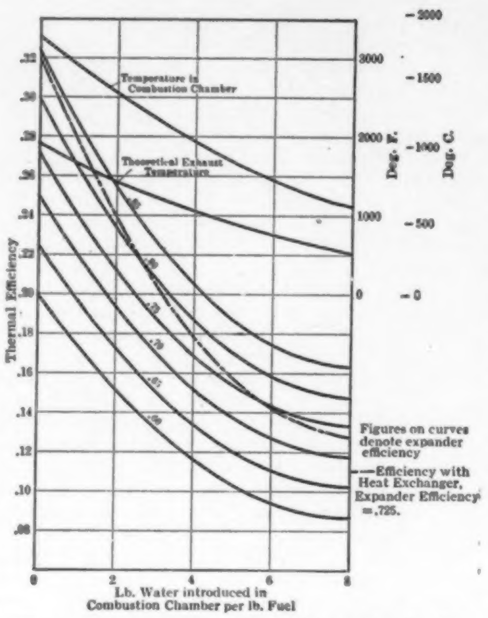
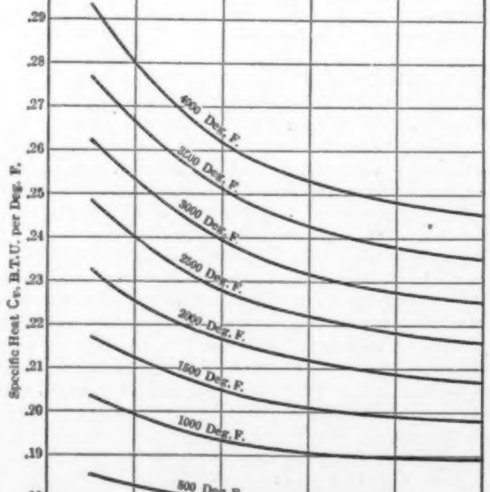


Chart showing effect of injecting water in the combustion chamber upon energy utilization

These possibilities are perfectly well known especially to inventors and investigators in the gas turbine field, and in spite of difficulties occurring in the practical realization of the compressor working process, these possibilities should continue to stimulate to further efforts in the field both of turbines and reciprocating engines. It may be well to point out what the difficulties are. First, the process is peculiarly sensitive to inefficiencies of compressor and expander. If both have an efficiency of 100 per cent then the margin of net work in the example above was found to be 75 per cent of the expansion work.

If the efficiency of the expander is reduced to 60 per cent, leaving 60 per cent of the expansion work available at the shaft and the efficiency of the compressor is also 60 per cent, it then requires $0.25 \div 0.60 = 42$ per cent of the theoretical expansion work to drive it. The margin left is $60 - 42 = 18$ per cent of the expansion work. At 50 per cent efficiency of both expander and compressor the margin disappears entirely. This is something that many investigators, thanks to the obscureness of ordinary mathmetical thermodynamics, have failed entirely to realize. It will then not do to operate with any sort of slipshod arrangements. The design must be such as to avoid as carefully as possible friction, throttling and cooling losses. This *can*, in my opinion, be done to the necessary extent at least in the case of reciprocating engines. In the case of turbines the rotation, or windage, losses in the turbine part and other turbulence losses in the centrifugal compressor part have proved most serious obstacles. All hope is by no means lost yet. If all the money spent in this field by workers with insufficient realization of what the nature of the problem demanded

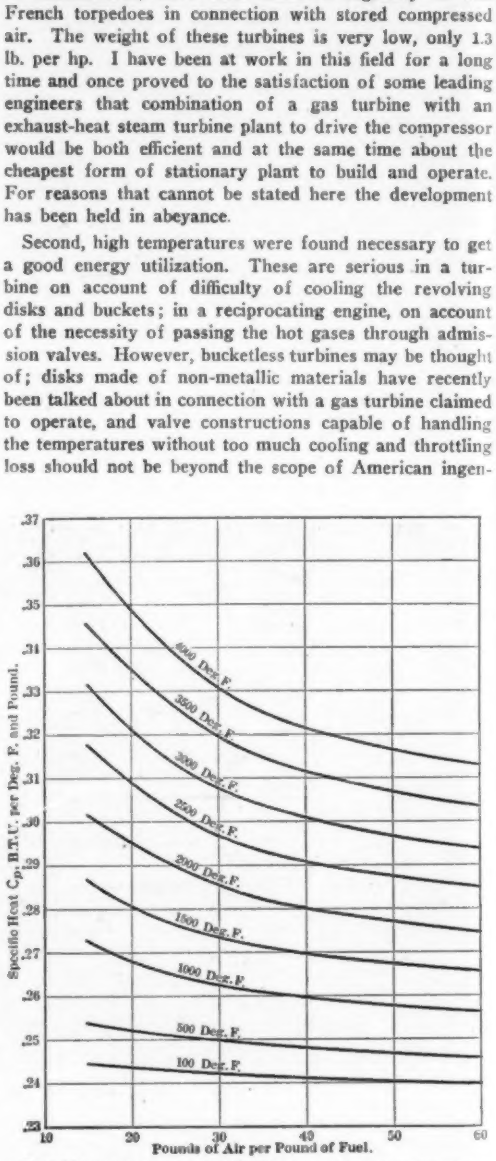


Specific heat curves for a constant volume of fuel

were spent over again by workers with sufficient scientific insight I think results could be produced.

For compressor engines as well as compressor turbines *have* run. Such an engine, aside from the Brayton design, is that of Kraus; such a turbine, that of Armengaud-Lemale, the combustion chamber and turbine wheel of which are shown. This outfit was successful enough to lead to the formation of a gas turbine corporation in France. The gas turbines of this company, while they are not used commercially for power production on account of inefficiencies, have been installed regularly to run French torpedoes in connection with stored compressed air. The weight of these turbines is very low, only 1.3 lb. per hp. I have been at work in this field for a long time and once proved to the satisfaction of some leading engineers that combination of a gas turbine with an exhaust-heat steam turbine plant to drive the compressor would be both efficient and at the same time about the cheapest form of stationary plant to build and operate. For reasons that cannot be stated here the development has been held in abeyance.

Second, high temperatures were found necessary to get a good energy utilization. These are serious in a turbine on account of difficulty of cooling the revolving disks and buckets; in a reciprocating engine, on account of the necessity of passing the hot gases through admission valves. However, bucketless turbines may be thought of; disks made of non-metallic materials have recently been talked about in connection with a gas turbine claimed to operate, and valve constructions capable of handling the temperatures without too much cooling and throttling loss should not be beyond the scope of American ingen-

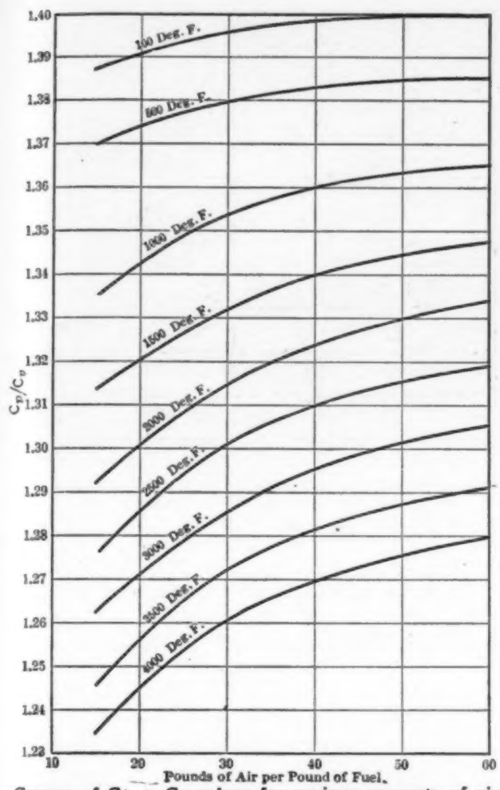


Specific heat curves for fuel at a constant pressure

uity. I have dabbled in the field and am on the whole full of hope. One solution, however, which has often been proposed, that of water injection in the combustion chamber, is fundamentally wrong from the standpoint of energy utilization.

A chart showing the conditions obtaining in this respect is reproduced. This is figured for an actual hydrocarbon fuel, burning with air, not for theoretical conditions. An isothermal compressor efficiency of 0.75 per cent has been assumed. Various expander efficiencies are given on the curve. The full lines give energy utilization without a heat interchanger, the broken dash line the utilization with an interchanger, allowing liberally for heat drop through the walls and allowing no temperatures that steel cannot stand easily. In short, this chart shows what a compressor engine may reasonably be expected to do when running with present-day apparatus on present-day fuel. It will be noticed that utilizations at least nearly equal to those of the Diesel engine may be looked for. The engine needs, however, on high-pressure compressor, has no tricky injection valves, no marvellously high-explosion pressure and yet will run on fuels if anything poorer than those of the Diesel or solid injection engines.

The curves are in thorough accord with such preliminary experiments as have been carried out. It should be noted, however, that water injection may reduce cooling losses to some extent and shift the expander efficiency from a lower curve to a higher. On these conditions, determinable only by experiment, I cannot here enter.



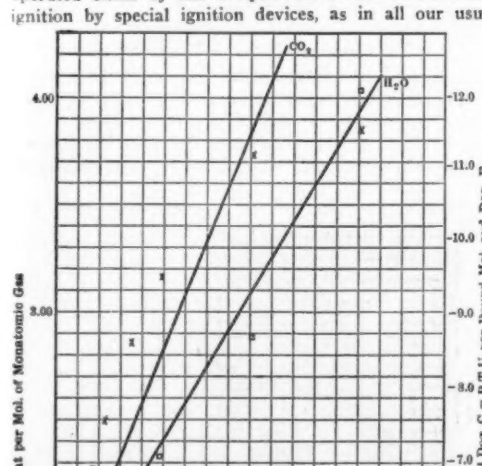
Curves of $C_p \div C_v$ values for various amounts of air

For those who wish to carry out calculations of this kind there are given a set of specific heat values and $C_p \div C_v$ values applicable to the combustion gases from gasoline or kerosene, also crude oil, with varying amounts of air. It is well known that these specific heats increase very considerably with the temperature, rendering calculations with constant specific heats or theoretical thermodynamic formulas based thereon highly inaccurate except for purposes of rough orientation. The curves are based on the most recent determinations by Nernst and others and the exact experimental data are given in another chart.

The indicator diagram of the compressor engine offers nothing of interest. It is a straight compressor diagram for the compression end and a diagram exactly similar to a steam diagram for the expander end.

COMBUSTION IN CONFINED SPACES.

The explosive process as introduced by Otto can be operated either by the compression of the mixture and ignition by special ignition devices, as in all our usual



Experimental data upon which the specific heat curves are based

automotive engines; or by the compression of the air alone and the injection of the fuel at the end of the compression stroke as is done in the hot-spot, the Hvid and the Brons engines. In the last two mentioned, which are really the same, the ignition is by the heat of compression only. In all these engines only part of the maximum pressure is secured by mechanical compression, the remainder is obtained by temperature increase due to combustion.

This renders the process less sensitive than that of the compressor engine to inefficiencies of compression. On the other hand, since the expansion ratio in an ordinary reciprocating engine can never be greater than the compression ratio, it is manifest that the expansion can never be carried to atmospheric pressure. A great deal of energy is left in the gases in the form of heat. This heat, as stated, cannot be applied advantageously to the working mixture in the same engine. Theoretically, therefore, the working process is less economical than that of the compressor engine with a heat interchanger.

The methods indicated in the previous paragraph have been applied to a process using a compression pressure of 300 lb., absolute, and a maximum temperature of 4,000°F., corresponding to a maximum pressure of 1,060 lb. absolute. The theoretical compression temperature is 800°F., a temperature that may well be expected to preignite any fuel capable of carburetion. The theoretical energy utilization of the engine is 58 per cent. With a compression efficiency of 90 per cent and an expansion efficiency of 80 per cent, the actual utilization of the engine would be 39 per cent. A higher utilization than this should never be expected from any engine using the ordinary explosion process. With fuel injection instead of carburetion higher compressions may be used, but the combustion will be less rapid.

Actually, Diesel engines with compression as high as 550 lb. have in the test stand reached utilizations of over 36 per cent. In these engines, as shown by the diagram, fuel injection by air is arranged so as to maintain a practically constant pressure for a short time interval. From the efficiency point of view this is a drawback. It means that the expansion ratio is less than the compression ratio. At full load or overload the pressure is sustained longer than at reduced load. Hence it is found that Diesel engines at reduced load often give better fuel economies than at full load. This is true until the diagram becomes so "lean" and the expansion work of the gases per stroke so small that it is consumed entirely in the mechanical running losses of the engine.

PISTON ENGINES.

The gain in efficiency due to increased expansion was clearly realized by early gas engine inventors. Charon, Atkinson, McGhee-Burt and others evolved means for obtaining expansion ratios in excess of the compression ratio. Charon on the compression stroke simply rejected part of the charge into the suction line. With a compression giving a mean *indicated* pressure of only some 43 lb. he attained energy utilization of from 26 to 27 per cent. Similar economies were attained by McGhee-Burt in spite of low mechanical efficiency due to double pistons in two cylinders. Also, Atkinson attained creditable results with his "differential" and "cycle" engines in spite of great mechanical complexity and consequently low mechanical efficiency.

Later on it was recognized that energy utilization could be materially improved by increased expansion due simply to increased compression and the complications of the "prolonged expansion" engines were scouted. However, if the expansion were carried almost to atmosphere with the assumptions used above, an actual energy utilization around 40 per cent might be attained. This is decidely worth striving for. Americans are strong in the development of ingenious, yet simple, mechanisms. Here is a problem well worthy of a gift of that kind.

For the practical man the two questions of more immediate importance are, however:

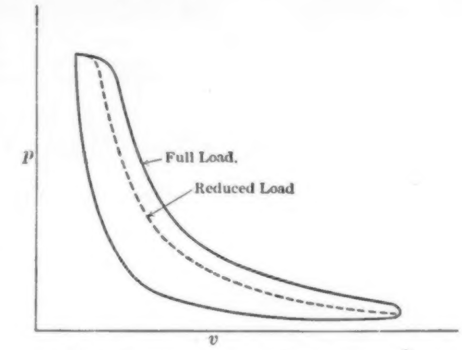
(1) What means have we for making the energy utilization of our ordinary carburetion engines approach the high values just given.

(2) What are the possibilities of replacing our present type of automotive engines with units of the injection type.

I must admit that I am fundamentally opposed to carbureters and electrical ignition devices. These elements are tricky and complicated laboratory instruments fundamentally differing from the kind of stuff we want to subject to rough handling by amateurs or busy practical men. Our efforts ought to be bent to the abolishment of this type of apparatus.

However, for those of us who nevertheless feel that a bird in the hand is better than ten in the woods, there are two main ways of attack: (1) The development of fuels allowing lighter compression. Excellent work along this line has been done by Rittman of the Bureau of Mines as well as by the organization headed by Past-president Kettering of this society and probably by others. (2) The perfection of the combustion process. With our present fuels, speeds, carburetion and ignition systems, the combustion in our automotive engines continues all through the expansion stroke, and 20 to 30 per cent of the fuel passes out unburned.

A great deal of very good work is at present being done on carburetion. Some good carbureters even for kerosene seem to be in the process of introduction. Some good scientific research is being carried out. In spite thereof it is not amiss to say that less invention and more scientific scrutiny is the need of the hour. There are close to 4,000 carbureter patents on file in the United States and of these not much over one in



Indicator diagram of a compressor engine

ten is worthy of any notice. We must as a nation come to understand that it is not practical common sense to spend years in trial and tinkering, when 2 weeks of concentrated scientific study might save all that trouble. After all our prodigious efforts it still was necessary for a Government committee during the war to state that we did not know the fundamental principles of the flow of air and liquids through small openings and could not intelligently design a carbureter if we wanted to. Yet all these things are easy to find out.

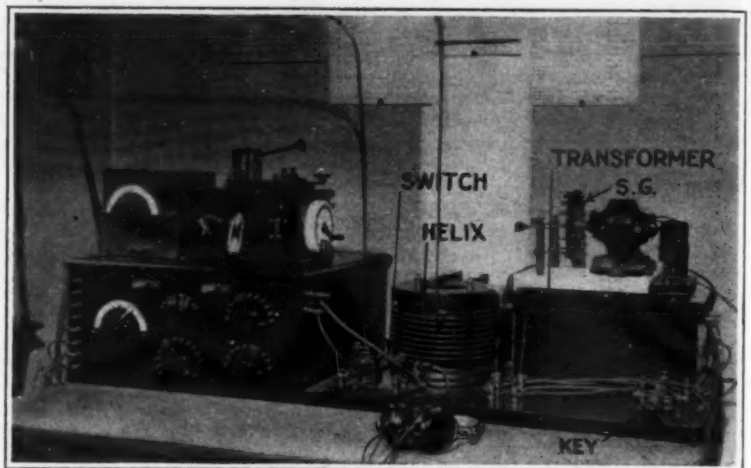
I have little faith in "fog" mixtures, carburetion by mechanical means only. Such carburetion is apt to be tricky. The best fog, is, however, undoubtedly produced by a liquid that has been in the state of complete evaporation. In this field, however, much better progress would be made if the formation of the fog were studied as a separate problem entirely apart from the engine, rather than by running engines on all kinds of devices and watching for carbon.

Combustion in the engine is accelerated by nothing more than turbulence. In the Gile engine compression takes place between the main piston and an auxiliary one superimposed on it. At the end of the compression stroke the mixture is forced through flutes in the wall into the combustion space. A violent turbulence and a thorough mixing are induced and the engine, according to analysis, gives extremely good combustion; at the expense, however, of a great increase in compression work. The fuel economy, while good, is therefore not suprisingly high. Here is a field for invention. Ignition at several points is a possiblity and also a complication.

One point on which there is much misunderstanding among practical men is the question of air heating. Hot air means high end temperature of compression. The maximum temperature producible does, however, not vary much. The ratio of maximum pressure to compression pressure is the same as the ratio of maximum temperature to compression temperature. Hence, with a higher compression temperature we get a lower maximum pressure. The power of the engine goes down. The compression work is a greater percentage of the expansion work and inefficiencies of compression are felt more in the efficiency of the engine. However, if by increasing the temperature of the air we can get a more perfect carburetion and combustion, this as a rule more than offsets the greater influence of compression inefficiencies. Perfect carburetion of present-day kerosene, according to my investigations as published in *Automatic Industries*, Feb. 27, 1919, requires a mixture temperature of about 220°F. and an air temperature before mixing of about 300°F. The temperatures for gasoline, if anybody can say what gasoline is, may be 100°F. for the mixture and 160° for the air.

(To be continued.)

A quenched-gap transmitter and receiving set suited to amateur use and small boats. The panel arrangement of the transmitter makes for neatness, convenience, and compactness



A typical amateur's equipment, consisting of a receiving set at the left and a transmitter at the right. Note the components of the transmitter, which are labelled. A rotary gap is used

Experimental Wireless Telegraphy and Telephony—X

Principles of Wireless Telegraph Transmitters and a Discussion of the Simple-Damped-Wave Sets

By Louis Gerard Pacent and Austin C. Lescarboura

For those who are satisfied to listen to what others have to say and make absolutely no reply, a receiving set is all that is required. And there are hundreds of thousands of amateurs throughout this country of ours who never go beyond the receiving stage, because they are satisfied to listen to the Government and commercial and amateur messages day after day. But if the amateur desires to do a little "talking" of his own, communicating with friends and making new acquaintances via radio, then he must resort to a trasmitter of some sort or other for generating the waves that serve to affect the apparatus in distant receiving stations.

What the Radio Transmitter Does

Electric waves, by means of which radio communication is carried on, are produced by the transmitting apparatus. Power must be supplied by some kind of electric generator; this must be converted into high frequency currents which flow in the transmitting aerial and cause electric waves which travel out through space. The waves may be damped or undamped. Damped waves consist of groups or trains of oscillations repeated at regular intervals, the amplitude of the oscillations in each train decreasing continuously as shown in Fig. 1. The number of these trains of waves per second is some audible frequency. When such waves strike a receiving apparatus, as we have already learned, they cause a tone in the telephone receiver. Signals are produced by means of a sending key, which lets the trains of waves go on for a short length of time (producing a dot) or a longer time (producing a dash).

The principles of damped and undamped waves are the same in many respects, so that much of what is told regarding damped wave apparatus applies to undamped waves as well. Particular attention is first given to damped waves, as the apparatus is simple and easily adjusted, and is particularly suited to amateur use. The next instalment of this series has to do with undamped wave transmitters.

Damped oscillations are produced when a condenser discharges in a circuit containing inductance. The condenser is discharged by placing it in series with a spark gap and applying a voltage that is high enough to break down or spark across the gap. Such an arrangement is presented in Fig. 2, where a transformer, supplied with current from a generator or battery, charges the condenser placed across its terminals, until the condenser charge has been built up to a point where the spark gap breaks down, permitting the pent up energy to discharge. In discharging the current passes through the inductance and sets up electric oscillations which are damped and soon die out. However, this action is again repeated after the transformer has had time to recharge the condenser. And so the action goes on, with a spark at regular intervals and an accompanying series of oscillations.

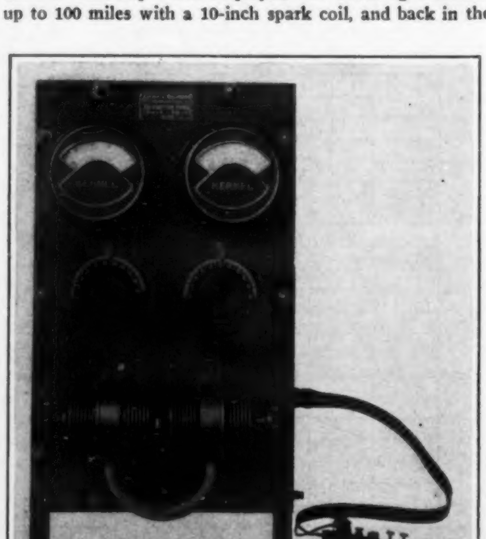
The standard generator frequency for most radio work is 500 cycles per second. This causes the condenser to discharge 1000 times per second, or once for each positive and each negative maximum if the spark gap is of such length as to break down at the maximum voltage given by the transformer. The number of sparks per second is called the "spark frequency." With the standard spark frequency of 1,000 per second the amount of power the set sends out is considerably greater than it would be at the low frequency like 60 cycles per second, because the transmitted radio waves are more nearly continuous. The radiated wave trains strike a receiving aerial more frequently and their amplitude does not need to be so great to produce the same effect as stronger waves received at longer intervals of time. The higher frequency produces a tone in the receiving telephones that is more easily heard, because the ear is more sensitive to sound waves of about 1,000 per second and also the tone is more easily heard through atmospheric disturbances. A 60-cycle supply may be used if the number of sparks per second is increased by the use of a rotary spark gap giving several sparks per cycle, as will be described further on.

The Simplest Types of Transmitters

Nothing could be simpler than the arrangement shown in Fig. 2, which depicts what is known as the "plain aerial" transmitter. Indeed, in the pioneer days of radio such a "hook-up" was employed for covering distances up to 100 miles with a 10-inch spark coil, and back in the

Portable receiver and transmitter. The transmitter occupies the lower half. The disk to the left is the quenched gap of special design. The interrupter is in the center foreground

Another amateur station with the long-wave receiver at the left and the transmitting equipment at the right. Note the rotary spark gap, loose-coupled transmitting inductance



Small quenched gap transmitter of the panel type, especially suited to the advanced amateur's requirements. The knobs control the wave length of the emitted waves and the motor-generator set

crude beginnings of amateur radio most amateurs made use of a spark coil and the plain aerial arrangement. In those days the transmitters were gaged by the inch; that is to say, the amateur talked of his transmitter by referring to its sparking distance, thus he had a two-inch, three-inch, or possibly six-inch spark coil, according to his monetary resources or constructive ingenuity, as the case might be.

The arrangement shown in Fig. 2 comprises a source of power, a means of raising the low voltage to a high one, say of 20,000 volts, which is sufficient to spark across a one-inch gap, a simple spark gap, a telegraph key for making and breaking the primary circuit, and the aerial and ground connection. When the key is pressed the power supply passes through the primary of the induction coil or transformer, as the case may be. When the current is broken, the secondary current flows out into the aerial and ground, which act as a condenser, accumulating the charge. When the charge reaches a certain point it can no longer be contained in the aerial-ground condenser, and consequently discharges across the spark gap, setting up oscillations in the aerial circuit.

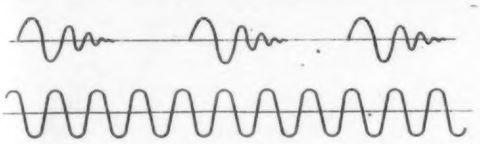


Fig. 1.—A graphic representation of damped and undamped waves

Simple as such a system may be, it is hardly permissible in general practice for the good reason that the waves emitted are of such high decrement that they cannot be readily tuned out in receiving apparatus when one does not desire to receive them. Any amateur of long experience can readily recall the days before the present wireless laws when it was possible, with even a one-inch coil and simple equipment, to prevent the most powerful stations from carrying on their business, because that one-inch coil monopolized the ether in its immediate vicinity. So it is little wonder that the radio laws put a stop to such transmitters and in their place insisted on transmitters whose emitted waves can be readily tuned out when desired bya receiving operator.

However, the plain aerial arrangement has other advantages besides simplicity. Its effectiveness is in cases where the sending operator wants all possible stations to hear him, as for instance when a ship needs help, and secondly, its military use in purposely drowning out or "jamming" other signals which an enemy is trying to receive. For amateur purposes, however, the plain aerial is now prohibited.

A modification of the plain aerial arrangement is shown in Fig. 4, which has a tuning inductance in the aerial circuit so that the wave length of the emitted waves may be varied. Placing a condenser in the aerial or ground lead has the contrary effect, namely, to shorten the emitted waves.

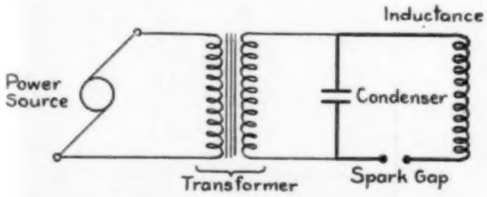


Fig. 2.—Simple oscillating circuit using a transformer, condenser, spark gap, and a few turns of inductance

Sharply-Tuned Transmitters

In order to emit sharp waves which come within the limits of the radio laws—these laws are described at length in the concluding instalment of this series—it is necessary to produce the oscillations in a closed circuit which is inductively coupled to the aerial or "open" circuit. Such an arrangement is shown in Fig. 5, where the induction coil or transformer serves to charge the condenser, which discharges across the spark gap and through the inductance. The inductance, it will be noted, forms part of the "closed" or oscillating circuit and also part of the aerial or "open" circuit. Thus it serves as an auto-transformer. Any number of turns of this inductance, which is made up of many turns of heavy wire or strip, may be cut into the closed circuit and into the open circuit, so as to establish the proper ratio between the circuits. The positions of the spark gap and condenser are sometimes interchanged, bringing the spark gap across the transformer. There is practically no difference in the operation.

In order to determine the proper number of turns for the closed and open circuits, the usual method for the amateur is to use a hot wire ammeter in the aerial circuit for measuring the aerial current, although for merely tuning to resonance a low resistance lamp such as a

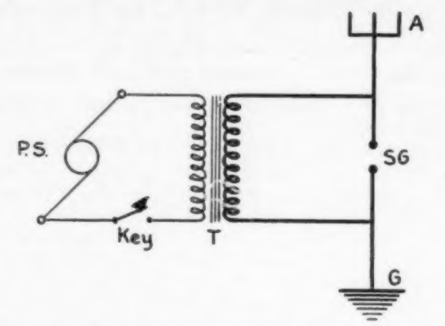


Fig. 3.—Plain aerial arrangement for a spark coil or transformer

small flashlight lamp may be used in place of the hot wire ammeter, the maximum current being indicated by the maximum brightness of the lamp filament. If the current is too great for the lamp it should be shunted by a short length of wire. The ammeter or lamp may be short circuited except when actually needed, in order to keep the resistance of the antenna circuit low. In practice the closed circuit is first adjusted to the desired wave length, which can be either estimated by some suitable means, or by the use of a wave meter. One method is to have a friend listen in on his receiving set, and determine when the emitted wave corresponds to other amateur transmitters whose wave lengths are known to be within the 200 meters required by the radio laws.

At any rate, with the closed or oscillating circuit tuned, the aerial or open circuit is then adjusted until the lamp or hot wire ammeter in the aerial circuit indicates

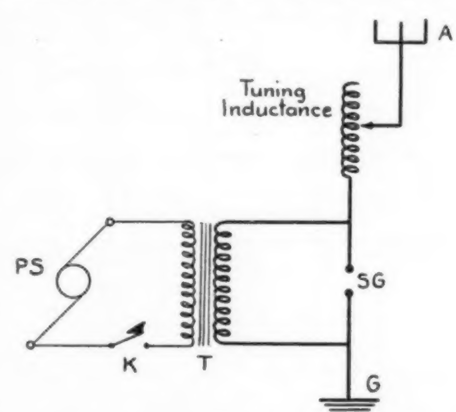


Fig. 4.—Plain aerial arrangement with inductance in the antenna lead in order to vary the wave length to some extent

the maximum output, proving that the two circuits are in resonance.

So much for the direct coupled transmitting set. There is another arrangement known as the loose-coupled set, which is shown in Fig. 6. Here the closed and the open circuits are absolutely isolated, although inductively coupled. Such an arrangement makes for very sharp waves and a high degree of efficiency. The coupling may be varied so as to obtain the best results, the adjustment depending largely on the type of gap employed.

Transmitting Condensers

The most common types of condensers used in radio transmitting circuits employ mica or glass as the dielectric, with tinfoil or thin copper as the conducting coatings. Compressed air and oil condensers are sometimes used, but they are bulky and certainly well out of the province of the amateur. For very high voltages the

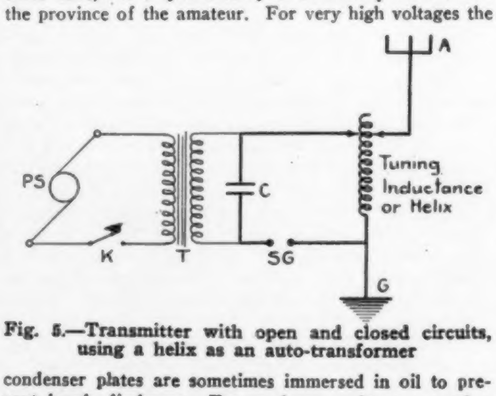


Fig. 5.—Transmitter with open and closed circuits, using a helix as an auto-transformer

condenser plates are sometimes immersed in oil to prevent brush discharge. For moderate voltage a coating of paraffin over glass plates, especially at the edges of the metal foil, will satisfactorily reduce brush discharge. Today, however, the amateur is fortunate in that his condenser problem is solved by purchasing one or the other of several manufactured condensers, which come in compact moulded units. A condenser of suitable size can be obtained in one unit, or built up of several units.

When the spark gap of a transmitter is broken down by the high voltage it becomes a conductor, and readily allows the oscillations of the condenser discharge to pass. During the interval between discharges the gap cools off and quickly becomes non-conducting again. If the gap did not resume its non-conducting condition, the condenser would not charge again, since it would be short-circuited by the gap, and further oscillations could not be produced. The restoration of the non-conducting state is called "quenching." A device called the quenched gap is described further on.

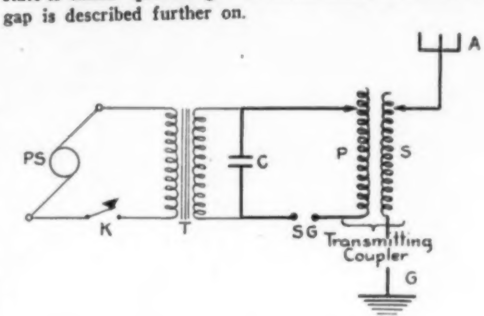


Fig. 6.—Transmitter using a loose-coupled arrangement for the closed and open circuits

Spark Gaps of All Kinds

A plain gap usually consists of two metal rods so arranged that their distance apart is closely adjustable. The gap must be kept cool, so that the discharge will not arc and to this end the rods are often provided with cooling fins. The length of the gap which can be employed is limited by the voltage that the transformer is capable of producing, the ability of the condenser dielectric to withstand the voltage, and the fact that for readable signals the spark discharge must be regular. If the gap is too long, sparks will not pass, or only at irregular intervals. If the gap is too short, it may arc and burn the electrodes. Even if no arc takes place, the voltage is reduced by too short a gap and this results in reduced power and range. The length for smooth operation can usually be determined by trial.

It is found that a short gap between cool electrodes is quenched very quickly, the air becoming non-conducting almost immediately after it has broken down, or as soon as the current falls to a low value. This action is also improved if the sparking chamber is air tight. The standard form of quenched gap, as such a gap is called, consists of a number of flat, copper or silver disks of large surface, say 7 cm. to 10 cm. in diameter at the sparking surface, with their faces separated about 0.2 mm. To provide the necessary total length

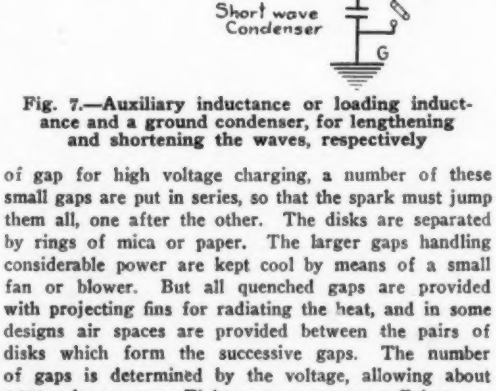


Fig. 7.—Auxiliary inductance or loading inductance and a ground condenser, for lengthening and shortening the waves, respectively

of gap for high voltage charging, a number of these small gaps are put in series, so that the spark must jump them all, one after the other. The disks are separated by rings of mica or paper. The larger gaps handling considerable power are kept cool by means of a small fan or blower. But all quenched gaps are provided with projecting fins for radiating the heat, and in some designs air spaces are provided between the pairs of disks which form the successive gaps. The number of gaps is determined by the voltage, allowing about 1,200 volts per gap. Eight or ten gaps are sufficient.

The quenched gap is not used in sets having a

(*Continued on page 360.*)

The Workman's Home—II

Suggestions as to How it Should be Financed and Built

By Leslie H. Allen

(Concluded from Scientific American Supplement No. 2290, Page 331)

A well-known cement maker bears all this out when he says: "All of our plants with one exception are so located that a large proportion of the employees live in adjacent cities or towns. The plant which is the exception has the largest turnover of labor that we have and we are now building some houses we hope will better conditions."

Mr. R. J. Caldwell, well known to all interested in good housing, compares our care of our workmen to our care of our tools—to the disadvantage of the former:

"Undoubtedly no class of Americans is more progressive generally than employers. They are keen for the quick adoption of any improvement in machinery, in facilities, in methods. Why is it that they are so slow to cultivate better relations with their employees, upon whom much more depends than on any machine? It cannot be because the question is difficult, for difficulties never deter an habitually successfull executive, whose success lies largely in his ability to overcome difficulties.

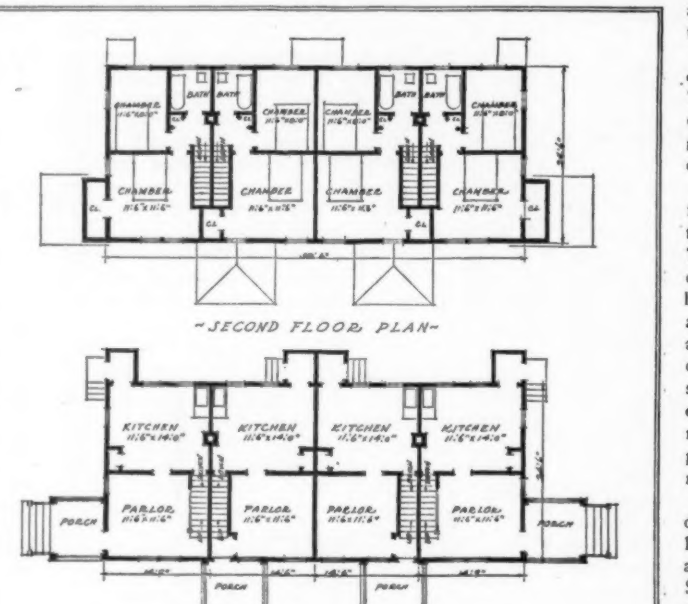
"Employers are very watchful of their machinery and take every precaution for its preservation and lubrication to insure its being maintained in good working order.

"What would an employer think of a superintendent who scrapped 50 per cent or even 15 per cent of his complement of machinery per annum? Yet that this record is common in labor turnover is evidence conclusive that lubrication is needed in relations between employers and employees. To scrap workmen is expensive, as every employer knows. New help is poor help. Inexperienced labor is inefficient labor, therefore costly labor. Low production per operative and per machine due to poor operatives means high costs in addition to low wages, so neither side is satisfied. Dissatisfaction results in more labor turnover and so the process continues interminably."

Here is a manufacturer in trouble. He states: "Our problem is housing single foreigners, who are more or less transient. They keep no heat during the day, freeze all water pipes, live without furniture, and have wrecking parties occasionally. Have suggested heated barracks with common lounging room, kitchen and food store, but they do not favor this on account of group likes and dislikes." Experiences like this are common where proper regulation and inspection is not carried out. But experience shows that even in the worst localities tenants can be made to live decently and treat houses properly.

The general impression gained from a study of these and many other letters establishes the following causes of labor turnover today:

- *a* Improper or insufficient housing
- *b* Inadequate transportation
- *c* The general restlessness due in part to the abnormal war conditions
- *d* "Misfits"—lack of care in employing men for work for which they are best fitted.



Four-family four-room houses built by the author's company two years ago at Killingby, Conn. Present cost about $9000 for the block of four

An important clause not touched on by any of my correspondents is the lack of proper relations between employer and employee, under which heading I would include lack of supervision of the hiring and firing of men, lack of care or interest in the men, friction with the labor unions, etc.

We cannot state definitely which of these is the most potent cause of trouble; but enough has been said to justify the statements made in the earlier parts of this paper on the supreme importance of good housing.

One of the striking points brought out in every investigation of the housing of the working classes is that the workman is never housed in a building designed to suit his needs. New houses are always built to suit the requirements of those above him in earning power and standards of living. When such houses become dilapidated or neighborhood conditions change he enters the houses and adapts himself to them as best he can. Comparatively few workingmen need a six- or seven-room house or can afford to occupy them without subletting half of the house or taking lodgers. Some of the worst housing conditions we find are in old mansions stranded by the receding tide of fashion and now occupied by four or five families, all sharing the same toilet and water supply.

The experiment is now being tried in many localities of building three- and four-room apartments and four- and five-room houses with much success. The workman as a rule does not desire to have the privacy of his home invaded by lodgers and welcomes the opportunity to live in a small house or apartment without them.

Any discussion of the kind of house he requires should be prefaced by a statement drawing a distinction between the skilled workmen and the unskilled. The former are usually Americans or live according to American standards; the latter are mostly foreigner-born or negroes, receive lower rates of pay and do not desire (or if they do desire, cannot afford) all the refinements and conveniences that are usually built in the American home.

I have been criticized for emphasizing this; particularly by those who are working for the Americanization of the foreigner. I sympathize with those who seem to see in my suggestions a lowering of the American standards of living, to which all should aspire and eventually be raised, standards that I endorse and ideals that I stand for also; but I stand my ground, realizing that the goal we aim for cannot be reached at one bound, and if we insist on building only that type of house which we think is ideal we shall be of no help in relieving the wretchedness of the present generation of unskilled workmen and their families. They may look with longing at the accommodations being built for them but they cannot afford to enjoy them and have to be content with the overcrowded tenements and old houses of divided occupancy that they now live in.

There is a certain minimum, however, that we all agree should govern the design of any workman's home. He should have at least one living room for general use of an area not less than 150 square feet entirely separate from his sleeping rooms, and he should have enough bedrooms for himself and for his children of different sexes to sleep apart, each bedroom having at least 400 cubic feet of air space per occupant, and every room having direct sunlight and ventilation through windows of ample size. Every tenant should have his own private toilet equipped with water closet and bath tub, and a sink with running water in the kitchen; all plumbing should be connected to the sewer and pure water for drinking should be supplied through faucets in the kitchen and bathroom.

American standards demand in addition separate parlors, separate dining rooms, pantries, large cellars, porches, furnace heat, electric light, laundry tubs, lavatory, bowls, etc. All these are desirable and should be provided if possible, but it is better to build whatever can be got for a reasonable cost than to add all these things and make the cost so high that it is out of reach of the tenant.

In discussing types, methods and materials of construction ought not to be omitted. The difference in the first cost between good construction and poor construction is not great and is speedily amortized in reduction of repair bills.

The difference in cost between a six-room frame house and one of brick, concrete or tile is at present prices less than 15 per cent. The price of the lot is the same in either case, so that the difference between a frame house costing $3000 and lot worth $600 and a brick house on the same lot would be about $450 or 8 per cent. Assuming 5 per cent. for interest, the saving of triennial outside painting would more than repay interest on his extra investment. By setting a lower rate for depreciation and amortization, it is possible to rent such a house at as low a rate as a frame house of the same size.

The greatest obstacle to the continuous development of industrial housing on right lines is the financial problem, so difficult alike for employee and employer to overcome. Speaking generally, most of our workmen, skilled or unskilled, are not home owners. The margin between income and living expenses is so small that the heavy initial payments required and the difficulty of clearing off second mortgages make it extremely difficult for a man below the grade of foreman to purchase his home.

Where a lot is purchased with the hope of building a home later, the hope is seldom realized, and frequently such a purchase is disastrous. The home seeker, misled by specious promoters, is faced with large unexpected assessments for betterments at inconvenient times and often loses all he has invested. He rarely accumulates enough funds to start building.

The manufacturer, too, is faced with similar difficulties. The amount of capital required to provide housing for his men is very much greater than the amount required to house his plant and machinery, and the administration of real estate either for rental or purchase presents many difficulties.

Company housing is necessary for a mine or other isolated industry. Textile mills and other industries paying a relatively low wage are forced into company housing at low rentals through the desire to keep wages down, but the shoe, automobile and other highly paid trades very rarely go into industrial housing work. But at the present time in order to keep down turnover and keep labor content, all trades are finding housing to be one of the burning questions of the hour.

Among the essential factors in the development of a housing enterprise are the following:

- *a.* The construction of permanent fire-resisting buildings which will not depreciate rapidly and therefore will serve as security for long-term loans.
- *b* The treatment of a housing development as an artistic whole by a competent city planner and architect so as to reap as large an increment as possible in the rise of real-estate values.
- *c* **The sale to the workmen of as many houses as possible on easy terms spread over a long period, the payments being arranged in a simple manner to cover insurance and taxes, as well as interest and repayments of principal**

d The establishment of a definite financial policy covering rented property, including the establishment of a sinking fund to take care of depreciation and obsolescence with the intention of amortizing the equity before the mortgages fall due

e The elimination of profit in selling the houses to workmen beyond a reasonable interest on investment

f Reducing the capital invested by selling a small proportion of the property in the open market at a reasonable profit

g Careful management of property and strict regulation of tenants particularly with regard to those who become nuisances or cause undue damage to property.

In entering the housing field on a large scale the manufacturer can utilize the services of the large general contractor who, buying at wholesale prices in the best market, and with well-trained gangs of men, can build at lower prices than the local speculative builder and produce better-built buildings. The cost of these buildings to the manufacturer is therefore considerably less than the real-estate value. In addition to this, the value of the land plus improvements is far more than the cost of the land and improvements, and this value usually increases year by year provided that values are kept alive by trading. The manufacturer is advised not to realize on this increase in land values when selling houses to his workmen, provided he can protect himself against the workman's turning around once he secures possession and doing it for him; but he is certainly justified in regaining some of this value by sales to other parties in the open market.

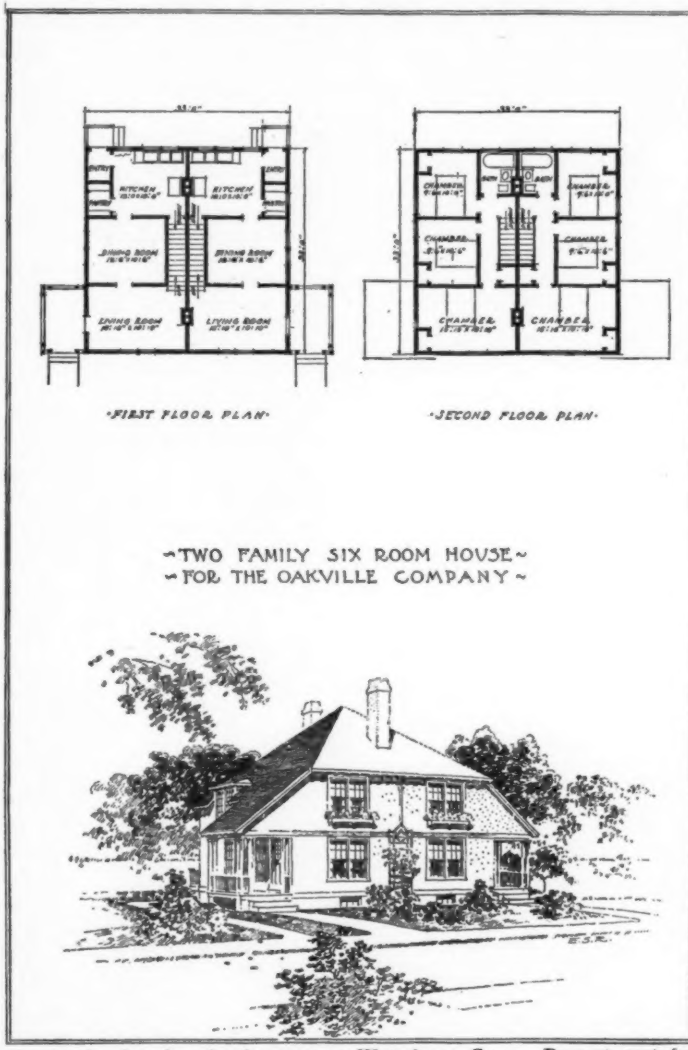
In the spring the writer surveyed a six-acre tract belonging to a Connecticut manufacturer. The land, acquired when the mill was built many years ago, was valueless for manufacturing buildings owing to its topography and location and had been written down on the books to a very low figure. Plans were prepared showing the improvements necessary to develop the land for housing, the cost of the improvements being estimated at $15,000. The value of the improved land after this work had been done was estimated by local real-estate men at $40,000. On this site it is planned to build housing for thirty-five families at a cost of $120,000. The estimated real-estate value of these buildings is placed at $132,000 as the manufacturer estimated that 10 per cent would be saved by having the whole development done at once by a good general contractor. The manufacturer plans to sell ten houses of this development in the open market at a price of $6000 each; his net expenditure would then be reduced to $75,000. The real-estate value of the premises unsold is estimated at $112,000, on which he plans to secure a mortgage of $50,000, leaving a net capital expenditure of $25,000 to secure housing for twenty-five families. These houses he plans to rent to his men, or sell at cost to those who wish to buy and will undertake not to resell within a specified time.

In order to protect against reselling it is advisable for the manufacturer to retain an option on the property if the man wishes to dispose of it. Another plan is that adopted by one company, who have added 25 per cent to the net cost of the improved land and buildings when selling, with the understanding that the 25 per cent would be returned or rebated in five years to the purchasers if they remained till then in the company's employ. After that they were free to dispose of the property at will. This seems to be a fair solution of the problem; it would be manifestly unjust to make the option or restriction a perpetual one.

The calculation of land increment may seem like the proverbial "counting your chickens before they are hatched" and cannot be reckoned on in every case. In most places, however, it holds true, a striking example being that of Gary, Indiana. According to a report by Dr. Haig to the Committee on New Industrial Towns, the cost of the town site was found to be $7,057,000. The cost of improvements was $4,030,000, making a total of $11,087,000. The value now stands at $33,445,000, an increase of $22,358,000 (over 200 per cent), all of which has been dissipated among private owners and speculators. A similar report by Mr. Swan on Lackawanna, New York, shows a land cost of $1,983,000, improvements $245,000—a total cost of $2,228,000. The value now stands at $9,026,000, an increment of $6,798,000 (over 300 per cent).

It is generally considered that it is in a man's best interest to own his own home. Several manufacturers are making it easy for him to do so by furnishing him the home at cost and accepting small monthly payments spread over a long term of years. It is found, for instance, at Indian Hill—a housing development at Worcester, Mass.—that a man can buy a $4000 home by a 10 per cent first payment followed by payments of $25 a month, plus taxes and insurance. His monthly payments take care of interest and refunding of second mortgage and in twelve years leave him with a first mortgage of $2500.

Added inducements, such as "term" life insurance for the value of the home for the repayment period, add very slightly to the cost per month, and secure the ownership of the equity to the wife in the event of the man's death. Some manufacturers prefer to pay taxes also and collect in monthly or weekly payments from the purchaser. In all these long-payment schemes the importance of good construction as a security against depreciation on long-term investment cannot be overemphasized. In conclusion, let it be said that the housing problem, while presenting many difficulties, is not an impossible one to solve, and it is the duty of us all to study it and endeavor to find a way in which the questions involved shall be happily and satisfactorily settled.



A superior housing development at Waterbury, Conn. Present cost for the two-family six-room house would be about $6500

Recovery of Fume from Silver Refining Operations

(*Concluded from page* 351.)

complete with oil gage and choke coils. The arrangement of the apparatus is such that the high-tension equipment of each set is completely screened off from the other set and from the low-tension apparatus.

The "path" of the electric power is from the generator at 220 volts, single phase, 60 cycles, through the switchboard control equipment and line rheostat to the transformer at the same frequency but at reduced voltage (line rheostat drop). The transformer "steps up" the voltage to about 65,000 volts and furnishes power at this voltage directly to the mechanical rectifier without going through any switching devices. Choke coils in the transformer circuit and resistances in the line afford protection against surges. The rectifier reverses the polarity of one-half of each complete cycle and supplies unidirectional current at about 65,000 volts to its main high-tension bus. One terminal of the rectifier is permanently grounded. Each rectifier is connected directly wothout switching devices to its individual high-tension bus. The three lines from the precipitator units are brought in through the wall of the building near the roof to three separate switching buses, which are so arranged that by means of a grounded mechanical remote control handle near the motor generator sets any or all of the three precipitator units may be connected to either of the main power buses. These switches can be operated with the buses alive, and the change over from one unit to another can be made in a very short time. It is good practice to reduce the voltage about 25 per cent before undertaking any high-tension switching. The high-tension switches are provided with padlocks so that a mechanic before going to work on a precipitator unit can lock the switch in an open position, take the key with him and be certain that the voltage cannot be applied to the unit upon which he is working, the operator meanwhile being free to manipulate the two other precipitator units without interference.

The Precipitator and Its Operator

The precipitator operates as close to 100 per cent clearance as any one can wish for, and this condition is always maintained on account of the high values in the fume recovered. As soon as this precipitator becomes overloaded with the precipitated fume in the precipitator pipes the operator can readily detect this condition by his instruments on the switchboard and by the general operation and appearance of the spark at the rectifier. The high-tension selector switches in the electrical equipment house are then operated, to cut in the spare unit; the jug dampers on the inlets to the units are opened or closed as the case may be to put the unit into service or to take it out. The precipitate is then washed from the pipes by means of the flushing system. This operation varies, due largely to the selenium content of the fume; the higher the percentage of selenium in the precipitated fume the more often it is necessary to take a unit out of operation to clean the collecting and discharge electrodes.

The recoveries, judging from the short time the precipitator has been in operation, will be even greater than those indicated by the preliminary single pipe tests based on which appropriations for the construction of the commercial installation were readily made.

Locating Defective Transmission-Line Insulators

An article in the *Electrical World* by T. F. Johnson, Jr., describes the "buzz-stick" method, which can be used to locate defective insulators of either the suspension or multi-part pin type. For the former it can be used at any voltage provided there are not fewer than two insulators per suspension or dead-end—there is no maximum limit, if the line voltage is not less than 20 per cent. of that insulated for. The condition of suspension insulators, from perfection to total failure, can be determined.

To use the test, the line must be alive—the test is, in fact, intended to assist in maintaining the lines without interruption of service.

The tool, for suspension insulators, is a treated stick 8 or 10 ft. long and 1¼ in. diameter, with an adjustable wire fork on one end, both prongs of which are electrically connected together. When the buzzer is touched on the line conductor and the insulator caps successively and drawn off slowly, "buzzing" sounds are produced which should continue to be audible until the feeding point is some 2½ or 3 in. away.

Three types of "buzz-stick," one for suspension and two for pin insulators, are illustrated, and the method of use is described in detail. It involves some danger until the operator acquires skill.

The buzz-stick method can be used to determine the proper number of suspension insulators to be used. The cost of testing by this method, including royalties, is from 1.5 to 3 cents per unit tested. The author claims that whereas a line which he instances was out 29 times (owing to insulator failures) in the year prior to the adoption of the buzz-stick, in the year subsequent to its adoption there was not a single interruption from this cause.—From *The Technical Review*.

Hospital for Disabled Locomotives

(*Concluded from page* 353)

the cutting. Thus, he may bring a tool point up close to one of the concentric surfaces already formed on the work. By slowly turning the lathe by hand, or otherwise, he can note whether the adjustment is just right or not. That is, he notes the space between the point and the surface as the turning goes on. If the space varies only a minute amount in the course of a full turn, he has the work set well. Now in a railroad shop, this kind of thing will have to be done time and again. For example, locomotive wheels—especially driving wheels—will call for resurfacing the tread, in order to remove the flat spots. The tires are the parts affected. To put such a tire on a face plate in exact position to make it possible to smooth out the tread with the least possible removal of metal, is a job calling for judgment and skill. Of course, the surface, over which the tool is to pass, must be free and clear. Nor is it permissible for the holding and centering devices to interfere in the slightest way with the mechanism involved in feeding and otherwise controlling the cutting tool. In the engraving, there is a clear view of a face-plate on which is held a locomotive wheel-tire by clamping devices. These clamps press centrifugally against the tire from the inside. They also provide rests in a vertical plane and clamping elements which hold the tire firmly in a proper vertical plane. That is to say, the tire is nowhere in actual contact with the face-plate, but is rigidly held in position, a short distance from it. The cutting head is located to the rear where the workman may be seen giving his attention. Apparently, he has already set the work and has begun cutting. I judge this from the tool marks on the tread. In handling annular pieces like this tire, care has to be exercised in connection with radial pressures from the center. If too great pressures are used, the ring may be somewhat distorted. The cut surface may be round while the work is on the lathe; but what will it be when the pressures are relieved and the sprung tire returns to its original condition?

There is one class of operation, which so far has received no explicit attention from us. This is welding by means of the oxy-acetylene torch or by the electric welding machine. These devices provide for the uniting of metals by a kind of soldering process; only with these modern appliances it is possible to replace the solder by a material closely approximating the rest of the work. Cast iron may be united to cast iron by means of iron. Brass may be joined to brass by means of brass. And so on. The new processes may be described as highly portable; so much so that oftentimes the welding operation may be carried out on the spot, where the locomotive or car is, without dismantlement. The new methods permit damaged fire-boxes in locomotives to be patched. In fact, by the use of a modified torch, the oxy-acetylene process may also be used to cut out the damaged plates. Certain of the electric methods likewise provide for cutting.

Electrostatic Effects on Airships

(*Continued from page* 359)

Metalic coating sprayed on by the Schoop process—Professor Wilder D. Bancroft, of Cornell, called attention to this recently invented process in a letter to the National Research Council. It is described in the *Metallurgical and Chemical Engineering Magazine*, vol. 8, p. 404, 1910, and vol. 11, p. 89, 1913. A sample is conducting and is coarse in structure. I have no doubt that a technique could be developed which would enable a thin conducting layer of aluminium to be sprayed on which would weigh not more than half an ounce per square yard.

Effect of the rubber insulation between the two plies of a balloon fabric—When the two plies are conducting they form, with the rubber insulation, a condenser of considerable capacity. A sample of cotton balloon fabric was tested and found able to withstand a difference of potential of over 10,000 volts between the two plies before a spark passed. But after a spark had once passed the insulation was no longer intact, and the difference of potential could not be raised to over a few hundred volts.

There are three cases to be considered. (1) If the two surfaces of a balloon fabric are conducting, the insulation will break down only at one point and more perforations will not result. (2) But if the two surfaces are insulating, sparks might pass at any point when the surfaces became charged up oppositely. (3) And if one layer is conducting while the other end is not, the chance of sparking differences of potential arising would be greatly increased by induction effects. This is another argument for making both surfaces of the balloon fabric conducting.

Perhaps a rapid and sure method of testing balloon fabrics might be developed along these lines. The fabric might be passed between two metallic rollers charged to a potential of 5,000 volts by means of an electrostatic machine. A spark would pass through any leaky spot and thus indicate its location as somewhere along the line of contact of the rollers. The precise point could be determined by shifting one roller sideways. An index of the quality of the fabric could be obtained from the number of sparks per yard, whether or not the precise location of the leaky spots was determined.

If a cotton-silk fabric is used it would be better to make the cotton ply the inner surface, as then its hygroscopic property can be used to keep it conducting. The silk ply will have to be made conducting by some one of the methods suggested above—at least in the neighborhood of the valves.

Loose joints—It is particularly important that all loose joints should be such as to ensure good electrical contact and prevent the possibility of a spark. Therefore no loose contact between iron and iron or between iron and anything else should be permitted, as iron oxide is a good insulator. Aluminium or brass should be used.—From *Aeronautics*.

Experimental Wireless Telegraphy and Telephony

(*Continued from page* 357)

supply frenquency as low as 60 cycles per second. The sparks obtained at that frequency are found to be irregular and not of good tone. For this case a rotary gap is used, as explained below. For 500-cycle supply the quenched gap is adjusted to break down at the maximum value of the applied voltage; that is, with its total length so adjusted as to give one spark for each half cycle of the emf. Discharges at other times are not possible, and as a result of this regularity a clear note is obtained. One advantage of the quenched gap is that it aids the production of a so-called pure wave. It also has the advantage of being noiseless, on account of the very short gaps and the enclosure of the spark.

A rotary gap consists of a wheel with projecting points or knobs, with a stationary electrode on each side of the wheel. The spark jumps from one stationary electrode to one of the moving points, flows across the wheel, and then, after leaping the corresponding gap on the other side, passes out at the second stationary electrode. The number of sparks per second is thus determined by the speed of the wheel which is motor driven, so that the signals of high pitch can be produced. An advantage of the rotary gap is its prevention of arcing, because of its motion and fanning action, and because the electrodes brought successively up to the spark gap have time to cool in their idle intervals.

In the case of a "synchronous" rotary gap the speed is so maintained as to bring the knobs near together at just the moment when the alternating voltage upon the condenser reaches its maximum value, positive and negative. Thus 500 cycles will produce 1000 sparks a second. This regular occurrence of the discharges gives smooth and efficient operation, and a pure musical tone. The synchronizing is made possible by attaching the rotating element of the spark gap to the shaft of the generator which charges the condenser. A rotary gap not so timed is called "non-synchronous."

Attempts to produce a high pitch with a 60-cycle source by a synchronous gap, giving, say, exactly six sparks per half cycle, have not given satisfaction, because the applied voltage is not the same at the time of the different sparks, and while the note is of high pitch, it is not musical. It has been found better to use a non-synchronous gap in such case, producing a large number of sparks per second and letting them occur wherever they may happen during the cycle. The irregularities will somewhat balance up. While the tone is not strictly musical, it can be made of high pitch. The non-synchronous gap is best used if nothing but a 60-cycle or other low-frequency source is available. Such a low frequency, however, is being avoided in modern apparatus, the standard frequency being 500 cycles per second. But for the amateur who cannot go to the expense and trouble of a small motor-generator set for generating a 500-cycle current, the rotary gap will be found quite satisfactory on 60-cycle supply.

For short distance communications, a spark coil and batteries can be employed. However, an induction coil of three-inch capacity or more soon exhausts any form of battery, so that it is well to operate the coil on power supply. For this purpose some suitable form of interrupter may be used, such as the mercury interrupter, one of the electrolytic type, or the magnetic type, through a suitable resistance. But, if current is available, the amateur might just as well use a transformer, since that affords the simplest operation and the highest efficiency. In fact, practically all amateur stations today use the closed-core transformer, which is obtained in several designs and many ratings at present. On direct current supply it is necessary, of course, to use a motor generator set to convert said current into alternating current. On alternating current lines of 60 cycles, the transformer can be used without further trouble.

For much of the foregoing material the authors are indebted to the Bureau of Standards, who have prepared Radio Pamphlet No. 40 for the Signal Corps, U. S. Army, containing the most comprehensible explanations of radio theories and radio practices as applied to military purposes.

In the next instalment the damped-wave transmitters will be dealt with, together with a few words regarding wireless telephone transmitters.

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